BULLETIN

OF

THE INSTITUTE OF PHYSICS

AND

THE PHYSICAL SOCIETY

VOLUME 12 . NUMBER 7 . JULY, 1961

CONTENTS

Some New Applications of Radar . E. Eastwood 181

Appeal for the Physics Trust Fund . . . 188

Education in the U.S.S.R. with Particular Reference to Physics . . J. L. Lewis 189

Notes and news 197

Forthcoming Conferences 197, 198

The Annual Dinner 199

Reviews of books 202

News of Members 209

Manuscripts accepted for publication in the Institute and Society's periodicals . . . 210

THE INSTITUTE OF PHYSICS AND THE PHYSICAL SOCIETY

Officers and Members of the Council, 1960-61

President:

SIR JOHN COCKCROFT, O.M., K.C.B., C.B.E., M.A., D.Sc., F.Inst.P., F.R.S.

Immediate Past-Presidents of the Institute and of the Society:

SIR GEORGE THOMSON, M.A., LL.D., Sc.D., Hon.F.Inst.P., F.R.S.
J. A. RATCLIFFE, C.B.E., M.A., F.R.S.

Vice-Presidents:

PROF. R. W. DITCHBURN, M.A., B.Sc., Ph.D., F.Inst.P.
A. J. PHILPOT, C.B.E., M.A., B.Sc., F.Inst.P.
W. H. TAYLOR, M.A., D.Sc., F.Inst.P.
J. TOPPING, M.Sc., Ph.D., F.Inst.P.

Honorary Treasurer:

J. TAYLOR, M.B.E., D.Sc., F.R.I.C., F.Inst.P.

Honorary Secretary:

C. G. WYNNE, B.A., Ph.D., F.Inst.P.

Ordinary Members of the Council:

PROF. C. C. BUTLER, B.Sc., Ph.D., A.Inst.P.
E. R. DAVIES, O.B.E., B.Sc., F.Inst.P.
PROF. B. H. FLOWERS, M.A., D.Sc.
J. M. A. LENIHAN, M.Sc., Ph.D., A.M.I.E.E., F.Inst.P.
G. R. NOAKES, M.A., F.Inst.P.
PROF. C. F. POWELL, M.A., Sc.D., F.R.S.
F. A. VICK, O.B.E., Ph.D., A.M.I.E.E., F.Inst.P.
PROF. D. A. WRIGHT, D.Sc., F.R.A.S., F.Inst.P.

Representing Branches:

M. R. HOPKINS, M.Sc., Ph.D., F.Inst.P.
PROF. H. LIPSON, M.A., D.Sc., F.Inst.P., F.R.S.

Executive Officers:

Secretary:

H. R. LANG, B.Sc., Ph.D., A.R.C.S., F.Inst.P.

Deputy Secretary:

N. CLARKE, B.Sc., F.Inst.P.

Editor and Deputy Secretary:

A. C. STICKLAND, M.Sc., Ph.D.

---

47 BELGRAVE SQUARE, LONDON, S.W.1. TELEPHONE: BELGRAVIA 6111

Appointments Vacant

The inclusion of particulars of a vacancy must not be taken to imply that the Institute and Society necessarily approves of the terms offered or that might be offered. Candidates should satisfy themselves that these are satisfactory, and they may always refer to the Institute and Society for advice.

MONASH UNIVERSITY
VICTORIA, AUSTRALIA
NEW ACADEMIC APPOINTMENTS

Monash University, which began teaching in March, 1961, with 350 students in the Faculties of Arts, Economics and Politics, Science, Engineering, and Medicine, invites applications for appointment to the following newly-established positions: CHAIR OF THEORETICAL PHYSICS; SENIOR LECTURESHIPS AND LECTURESHIPS IN PHYSICS (One Lectureship in Theoretical Physics). The current research interests of the Department are in the fields of Magnetism, Low Temperature Physics, Radio frequency Spectroscopy and Solid State Physics. Salary scales: Professors: Minimum of £A4,000; Senior Lecturers: £A2,480–£A2,950. Lecturers: £A1,660–£A2,360. Full information on application procedure, conditions of appointment, superannuation, travel and removal allowances, study leave and housing is available from The Secretary of the Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1, or from the Registrar of the University. Technical enquiries should be addressed to the Head of the Physics Department, Professor R. Street. Closing date: Applications close with the Registrar of the University on July 31, 1961. F. H. Johnson, Registrar.

THE UNIVERSITY OF SOUTHAMPTON
PHYSICS DEPARTMENT

Applications are invited for research fellowships and studentships to work in the surface physics group. The work, which is sponsored by the Atomic Energy Research Establishment, will involve the application of ultra-high vacuum, photoelectric and work function techniques to investigations with low work function surfaces. The fellowships valued at £900 p.a. and tenable for two years, will include F.S.S.U. benefits. The studentships, which may lead to a higher degree, are valued up to £415 p.a. together with demonstrating fees. Applications, quoting two referees, should be sent to the Secretary and Registrar, The University, Southampton, not later than August 1, 1961.

DIRECTORY OF OPPORTUNITIES FOR QUALIFIED MEN

Available free of charge to applicants with Institute membership or H.N.C. A most comprehensive guide to employment opportunities. Write, stating qualifications to Department C, Cornmarket Press Ltd., 1 Lower James Street, London, W.1.

NORTHAMPTON COLLEGE OF ADVANCED TECHNOLOGY
ST. JOHN STREET, LONDON, E.C.1
ASSISTANT LECTURER

Applications are invited from scientists or engineers with an interest in basic or applied measurements and/or automatic control for the post of Assistant Lecturer in the Department of Production Technology and Control Engineering. The Department is engaged in teaching measurements and automatic control at Diploma of Technology and Postgraduate level. Applicants should have an honours degree or a Diploma in Technology. There are facilities for research and study for higher qualifications. Salary on Burnham Scale £930 rising to £1390 depending on qualifications and experience. Forms and particulars from the Secretary.

EXPERIMENTAL OFFICER required by ROYAL MILITARY COLLEGE OF SCIENCE, SHRIVENHAM, BERKSHIRE, to provide for testing, maintenance, calibration and repair of nuclear electronic apparatus, and maintenance of high intensity radiation generators. Opportunity to assist in research work. Candidates should have considerable experience with electronic equipment or, preferably, nucleonic equipment. Qualified man encouraged to do personal research for higher degrees. Qualifications:—G.C.E. (A-level), Pass degree, H.N.C. or equivalent. Salary: £1,057 – £1,296. Starting salary allows credit for approved postgraduate experience and National Service. Opportunity for establishment and promotion. Quarters available for single man, possibility of house for married man. Forms from Ministry of Labour, Technical and Scientific Register (K), 26 King Street, London, S.W.1. quoting reference A.253/1A.

IMPERIAL COLLEGE OF SCIENCE AND TECHNOLOGY

Applications are invited for a senior Research Assistantship for work on the PRODUCTION AND UTILIZATION OF AUGMENTED ION CONCENTRATIONS IN FLAME PLASMA. Commencing salary (approximating to lecturership), depending upon qualifications and experience, up to £1,125 p.a. with family allowances and F.S.S.U. benefits. Preference will be given to candidates with research experience in the physics of discharges or allied fields of gaseous electronics. Applications, with details of career and qualifications, to Dr. F. J. Weinberg, Chemical Engineering Dept., Imperial College, London, S.W.7.

IMPERIAL COLLEGE OF SCIENCE AND TECHNOLOGY PHYSICS DEPARTMENT

Applications are invited for the following posts in the photo-electronics section: LECTURER. Salary in range £1050 × £50 – £1400 × £75 – £1550 (bar) × £75 – £1850 per annum, plus £60 per annum London Allowance and Family Allowance of £50 per child per annum. F.S.S.U. Membership. Duties include teaching General Physics and special Advanced Course, research in application of photoelectronics to nuclear physics, astronomy, space research, etc. RESEARCH ASSISTANT (Academic) to assist in research in the fields of vacuum physics and photoelectronics. A good degree essential and some research experience preferable. Salary in range £700 – £1100 per annum, depending upon qualifications, plus Family Allowance. F.S.S.U. membership. Apply, with full personal and academic details and names of two referees, to Professor J. D. McGee, Physics Department, Imperial College of Science and Technology, London, S.W.7.

THE ROYAL COLLEGE, NAIROBI

Applications are invited for (*a*) SENIOR LECTURESHIP, or (*b*) LECTURESHIP IN PHYSICS. Previous research experience (theoretical or experimental) in upper atmospheric physics and in palaeomagnetism or an allied subject would be valuable. Salary scales: (*a*) £1,950 × £75 – £2,475 p.a., (*b*) £1,350 × £51 – £1,707 × £72 – £1,851 × £75 – £2,151 p.a., entry point determined by qualifications and experience. F.S.S.U. Child allowance £50 p.a. per child (max. £150 p.a.). Passages for appointee and family (up to four adult passages) on appointment, termination and leave (once every two years). Rent according to quarters provided £60 – £114 p.a. Detailed applications (6 copies) naming 3 referees by July 26, 1961, to Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1, from whom further particulars may be obtained.

An Assistant Experimental Officer is required for the Biophysics Department of the RESEARCH INSTITUTE (ANIMAL VIRUS DISEASES), PIRBRIGHT, SURREY. The work involves the application of physical methods such as electron microscopy, electrophoresis, light-scattering, high-speed centrifugation and spectroscopy to the investigation of the structure and properties of animal viruses. Applicants over 22 should have H.N.C. or equivalent. Salary dependent on age and qualifications in A.E.O. scale £625 at age 22 rising to £983. House available for married applicant. Superannuation scheme. Applications to Secretary.

ANALOGUE COMPUTOR

This instrument provides a first introduction to the practical aspects of analogue computation, such as scaling and the choice of time-constants, without the complexity of a full-scale computer. It is primarily intended for use by students in the engineering departments of Universities and Technical Colleges but would also be extremely valuable as a demonstration aid for mathematics students in the Sixth Form of schools. Solutions may be displayed on any simple cathode-ray oscilloscope (an afterglow screen is not required).

Containing four amplifiers, it permits the solution of linear differential equations of up to the third order and the simulation of any dynamical system described by such equations.

For example, it is eminently suitable for studying all the basic methods of stabilizing servomechanisms. With additional networks and non-linear circuits, higher order and non-linear equations may be studied. It works either repetitively at 25 c/s, for the study of transient responses or continuously when it may be used in conjunction with any simple audio-frequency oscillator for the study of resonance responses.

Designed by P. L. Taylor, M.A., A.M.I.E.E.

FCR

F. C. ROBINSON & PARTNERS LTD.

Specialists in Instrumentation

COUNCILLOR LANE, CHEADLE, CHESHIRE.

Telephone: Gatley 2469/4020.

COURTAULDS

Instrument Engineers or Physicists

COURTAULDS requires Instrument Engineers or Physicists for their Research and Development Organization at Coventry.

Vacancies exist for suitably qualified men:—

(1) To develop from first principles, analytical and other instruments based on original ideas.

(2) To join a Group providing a complete process control instrumentation service for the three major units of the Research and Development Organization at Coventry.

Applicants, who should be under 35 years of age, should have a Ph.D. or a good honours Degree in Physics, Mechanical or Electrical Engineering. A flair for instrumentation, coupled with some experience in either the application of instruments and computers to the control of chemical and physical processes, or the design and development of instruments, is essential.

Candidates should write for a detailed form of application to the Director of Personnel, Courtaulds Limited, 16 St. Martin's-le-Grand. London, E.C.1, quoting reference number D.9/3,

ENGLISH ELECTRIC VALVE CO. LTD.

Chelmsford, Essex

The Company has in production high quality germanium and silicon power rectifiers in ratings up to 20 amps.

Improvement in the processes involved in the manufacture of these devices continues in order to increase their reliability in service.

The Company wishes to engage a senior production-development engineer to accept responsibility in the development and production of the rectifiers in current demand, and other devices that the Company wish to market after development.

A substantial salary will be paid to an engineer or physicist possessing sound experience in the semi-conductor field and postgraduate qualifications. Preferred age range 28 to 40.

Applications outlining experience and qualifications should be sent to:

Group Personnel Services, English Electric House, Strand, London, W.C.2

Please quote reference IP 1594.K.

Insurances for Physicists

☐ **RETIREMENT PENSIONS** with full Tax Relief (1956 Finance Act)

☐ **ENDOWMENT ASSURANCE.** An adaptable policy providing protection for dependants, a good investment and a Tax-free capital sum on retirement.

☐ **NON-CANCELLABLE SICKNESS AND ACCIDENT INSURANCE,** providing an income during disablement up to age 65.

☐ **HOUSEHOLDERS COMPREHENSIVE INSURANCE** on Buildings and/or Contents with No Claims Bonus.

☐ **MOTOR INSURANCE.** Special Scheme with immediate 33⅓% No Claims Bonus
(PLEASE SEND DETAILS OF CAR FOR QUOTATION PURPOSES)

Name..... Date of Birth.....
(BLOCK LETTERS PLEASE)

Address .....

These policies are of particular interest to physicists.

For further details please complete this form and send to:

WALTER HERRIOT & CO. LTD.

Incorporated Insurance Brokers

Broad Street House, 54 Old Broad Street, London, E.C.2

(Telephone: LONdon Wall 7007/8)

Scientists in Production...

B Nylon S

PHYSICISTS & CHEMISTS

at Pontypool, Doncaster, Gloucester

The work is of an applied nature involving the control and improvement of processes in the production areas. Also the evaluation of equipment to determine its acceptability for production purposes.

These positions are suitable for experienced men who have ambitions in Production Management, and who wish to make a break from the laboratory bench.

The work, which is varied, interesting and often original, will provide necessary experience to men who are looking for promotion and prospects in industry.

Technical officers are given a free hand, within reason, to enable them to make the best use of original ideas.

Continued expansion of production activities provides excellent prospects.

Generous assistance is given to married men moving into the area.

Applicants are invited to write, quoting reference D. 143, to:

The Personnel Manager,

British Nylon Spinners Limited

PONTYPOOL, MONMOUTHSHIRE

UNITED KINGDOM ATOMIC ENERGY AUTHORITY

TWO EXPERIMENTALISTS IN APPLIED PHYSICS

are required by

THE RADIOCHEMICAL CENTRE

(Ref. 5/61/110) An EXPERIMENTAL PHYSICIST is required at Amersham to lead a team engaged on the operational control of radiological exposure. A wide variety of alpha and beta emitting nuclides are handled and protection measurements include breath sampling and gamma spectrometry.

(Ref. 8/61/110) An EXPERIMENTAL PHYSICIST is required for the Isotope Production Unit at Atomic Energy Research Establishment, Harwell, to take charge of a small physics team whose work includes the provision, maintenance and calibration of all electronic measuring equipment used by the Unit, the measurement of pile flux and the radiation characteristics of materials after irradiation.

Applicants must be over 26 years of age and a pass degree in Physics or a Higher National Certificate in Applied Physics is desirable. For the first post operational experience in Health Physics and, for the second, experience in experimental nuclear and radiation physics and some knowledge of electronics are desirable.

The appointments will be in the grade of Experimental Officer and starting salaries will be based on experience within the range of **£1,165–£1,430**.

Both posts are Superannuable and financial assistance may be given towards the purchase of a house.

Apply to the Personnel Officer, the Radiochemical Centre, Amersham, Bucks, quoting the appropriate reference.

BULLETIN
OF
THE INSTITUTE OF PHYSICS
AND
THE PHYSICAL SOCIETY

Vol. 12, No. 7 JULY, 1961

Some New Applications of Radar

E. EASTWOOD
M.Sc., Ph.D., M.I.E.E.
(*Marconi Research Laboratory, Great Baddow, Essex*)

[A Lecture given to the London and Home Counties Branch on January 23, 1961]

THE rapid progress of radar from the first demonstration of feasibility to its emergence as a decisive military weapon was rendered possible by the technical capital in the worlds of physics and short-wave radio that could be drawn upon by the first radar engineers. In the microwave field in particular radar was heavily indebted to the physicists; even in the turmoil of war however, it was apparent that radar would ultimately be able to repay this debt and would supply the research physicist with new tools that would permit him to explore many new fields of knowledge. Radio astronomy and microwave spectroscopy show how this debt of radar to physics is being repaid.

In the early years following the war the work on radar research was greatly reduced and the radar stations were taken out of service, since those responsible for the conduct of civil aviation did not believe that the wartime network of ground radar stations could contribute significantly or economically to the control of civil air traffic. The hopes for true peace however, were not fulfilled and by 1948 it had become apparent that the country would do well to look to its radar defences. Mere restitution of the wartime chain of stations would not have been effective because of the changed operational requirement and in designing the new stations it was clear that account would have to be taken of a new threat consequent upon a realigned Europe.

Although the short range ballistic missile had entered the combat field at the end of the war the major threat in 1948 was still considered to arise from massed raids of winged bombers operating both higher and faster. Really low level penetration of enemy aircraft still retained its importance and it was assumed that counter measures such as widespread window* would be used. This was the period when the ground-to-air and air-to-air guided weapon programme was mounted and so the radar environment had to provide for a countrywide defence with complete co-ordination of the interceptor and guided weapon arms. The radar objective became comprehensive cover and complete tracking within autonomous defence areas. The development work which sought to translate this tactical objective into equipment and techniques resulted in a further generation of radars whose performance was in all respects greatly superior to that of the wartime equipments.

The philosophy of defence during these turbulent years however, underwent many changes so that many of the radars projected in accordance with the 1948 assessment of the threat were outmoded by the march of events and never achieved operational status. There are some who would say that the development of these discarded systems has been wasteful of the country's technical effort, but this is not so since the techniques that were evolved were necessary steps in the evolution of the art of radar design. In addition, these by-products that have emerged in the progress towards the solution of the air defence problem have placed new tools in the hands of the Air Traffic Control authorities at an opportune moment when it is possible to match the civil radar environment to the numbers and types of new aircraft that are now to be operated. Further, and what is more relevant from the point of view of the present paper, these new radar tools have once again found ready application in other fields of research and are materially adding to the common stock of knowledge in fields so remote from military electronics as bird migration and the nature of the particle stream incident upon the earth from the sun during solar eruptions—once again the swords have been beaten into ploughshares!

* Thin strips of metal dropped from aircraft to confuse hostile radar.

TRENDS IN RADAR DEVELOPMENT

The improvements in radar technique that have resulted from the endeavour to meet the above operational requirement may be briefly reviewed as follows:

Transmitters

The wartime microwave radars operated at S-band and achieved a power in the order of 500 kW for a pulse length of 2 μsec. Single frequency operation however, is obviously dangerous in view of the possibility of elec-

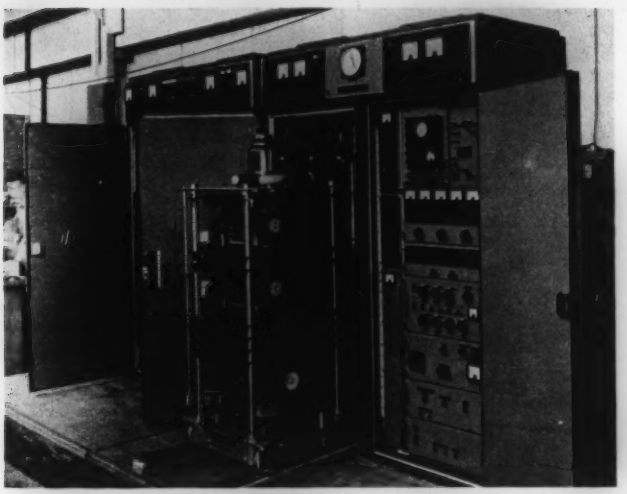

Fig. 1. *Klystron Amplifier Radar Transmitter (600 Mc/s)*

tronic jamming and of propagation difficulties. It was therefore necessary to create generators at other frequencies together with their associated microwave components. The power of the new transmitters was simultaneously increased by an order of magnitude; the radar which has been used in some of the experimental work presented in this paper is an example of this work. It provides power of $2\frac{1}{2}$ MW (5 μsec) in the waveband 1200–1400 Mc/s, i.e. L-band, and is based upon the magnetron tube.

Pressure of events during the war did not permit effort to be applied to the development of the klystron as a power generator. The klystron however, offers the hope of achieving even higher pulse powers than those of which the magnetron is capable; it also permits advantage to be taken of pulse to pulse coherence since the klystron can be operated in the amplifier mode by accepting drive from a crystal source. Fig. 1 shows a fully coherent klystron radar transmitter which operates at 600 Mc/s and delivers a power of half a megawatt. This radar is of particular value to the civil authorities in that its longer wavelength ensures greatly reduced precipitation returns whilst the coherence permits the total elimination of any residual signals of this type and also of the unwanted ground returns.

In order to contain this greatly increased power from magnetrons and klystron generators it has been necessary to develop duplexing devices based upon gas discharge tubes contained in appropriate waveguide couplers. The difficulty of this problem can be assessed when it is remembered that the receiver is capable of detecting power of the order of 10^{-15} watts and yet has to be protected against an outgoing power of 10^{6} watts; a protection ratio of 10^{21} is no mean performance to achieve in such a type of gas discharge device.

Receivers

The wartime microwave receiver saw a return to the crystal method familiar from the early days of broadcasting since no tubes existed capable of operating at these high frequencies. The great upsurge of interest in semiconductors since 1948 has produced developments in microwave crystal detectors so that it is now quite practicable to achieve and hold noise figures of 7 dbs in simple crystal receivers. More recently, the development of the travelling wave tube has permitted the all-electronic receiver to be employed in commercial radar systems. Although the travelling-wave tube has not improved the performance of the receiver significantly relative to a good crystal receiver, it has certainly ensured constancy of performance of the radar since the electronic receiver does not suffer any degradation from the integration of the residual spike break-through. More recently still, a further substantial improvement in receiver performance has been possible through application of the parametric amplifier based upon the Adler tube. The 600 Mc/s radar mentioned above now employs such a receiver and yields a noise figure in the order of 4 db.

Signal Processing

Mention has been made of the need to remove unwanted clutter from the planned position indicator

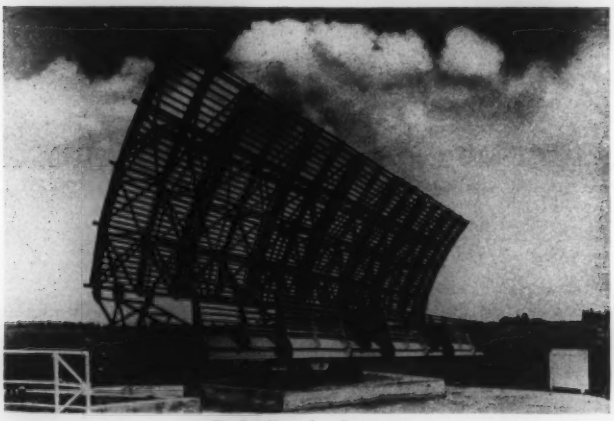

Fig. 2. *Narrow beam linear array.*

(P.P.I.) whilst leaving the echoes from the aircraft unaffected. These years have seen intensive study of the problem of Moving Target Indication (M.T.I.). This technique in its simplest form utilizes the Doppler principle and its realization demands very high stability in the apparatus as well as the provision of special components such as delay cells. In a more sophisticated form of M.T.I. it is possible to control the phase of the reference oscillator by the position of the antenna so that it becomes possible to eliminate not only the echoes from fixed targets but also the returns from clouds which are moving at a constant velocity. This application of the Doppler principle is greatly facilitated by the use of a coherent transmitter and explains the great interest in the klystron and travelling wave ampifiers.

Aerials

Great attention has been paid to aerial design during this period in order to improve both the gain and the resolving power whilst seeking to reduce the amplitudes of the sidelobes in the aerial's radiation diagram. Large radar aerials are almost invariably of the reflection type in which beam shaping is achieved either by the curvature of the reflector or by the control of amplitude and phase from a linear array of slots in a waveguide. Fig. 2 illustrates a typical aerial of this type; this is a large 50 cm antenna of the linear array type which is now coming into operation with the civil authorities and which has been used in some of the research investigations described later.

Display and Data Handling

One of the most important developments, certainly from the point of view of the utilization of radar in civil or military operations, has been the development of display units which provide both improved accuracy and perception factor. This major step forward in the technique of radar display has been made possible by the application of the fixed coil principle and by the development of cathode ray tubes greatly improved as regards focus and afterglow characteristics. These new displays make use of marker symbols painted during the radar intertrace period and with their aid it is now possible to extract and edit the essential radar information free from the effects of clutter and other irrelevant information. It is this type of display which has made possible the detailed analysis of the phenomena described below. In particular, any portion of the P.P.I. defined by the azimuthal spread θ and the range interval R can be presented upon a separate B-scope display in which cartesian co-ordinates are employed. Since the same volume of space is now presented upon a much larger area we have achieved the equivalent of a "radar microscope " which allows us to examine the fine detail of a phenomenon. In addition, both P.P.I. and B-scope displays can be photographed on ciné film such that the information generated during a single scan of the aerial is recorded upon a single frame of the film. If the film is subsequently projected at the normal speed of 16 frames per second then, for the normal rotational aerial speed of 4 r.p.m., a time compression of 240 is achieved. This form of presentation emphasizes the time variation of any particular phenomenon and has made a great contribution to the study of the movements of both ring angels and the reflecting regions of the aurora.

Research Applications

It is with radars embodying the above advances in technique that the research studies described below have been conducted. The topics selected for discussion

Fig. 3. *Ring Angel—February 17, 1959*

will serve to show that the new radars are indeed making a worthwhile contribution to pure research.

ANGELS AND BIRDS

In addition to the aircraft which it is the purpose of the radar to detect, there are often present on the P.P.I. many unwanted signals or "spurious echoes" which confuse the picture and may even mask the desired aircraft targets. The origin of many such echoes is now well understood and the scattering objects that produce many permanent echoes include buildings, trees and high ground, while moving "clutter" may arise from srain clouds and snow storms. These unwanted signal may be removed by the Doppler-derived M.T.I. technique already mentioned. The method is less successful however, when applied against another class of moving point targets to which the designation "Angels" was given when there were few clues as to the nature of the scattering sources. The study of radar angels has led to a new subject which may be termed Radar Biology in that it is the behaviour of birds and even insects which comes under observation.

From observations made during the war on the 1½ metre coastal watching radars it was known that ducks, geese and swans could produce echoes upon the P.P.I. It hardly seemed credible however, that the intense displays of angels which are often visible on the P.P.I. of a modern high power radar could all be ascribed to birds. Careful observation soon revealed that angels were not wholly windborne and in 1957, W. H. Harper was able to demonstrate from radar observations taken at the Dunstable Meteorological station that the tracks followed by a high percentage of angels corresponded with the usual flight paths of migrant birds in this region. Detailed analysis by Tedd and Lack of the angels seen on a high power, 10 cm radar sited near Cromer showed that the diurnal and seasonal variation in intensity of the angels correlated with the habits of migrant birds. Later, studies by Dr. Lack have traced the movement of the migrants and shown the value of radar in this kind of field work. Sutter in Switzerland has similarly shown how radar may be used to follow the flight paths of bird migrants through the Swiss valleys.

The Marconi Experimental Radar Station at Bushy Hill in Essex is very favourably located for the observation of bird movements to and from the continent. Systematic cine recordings over a period of two and a half years have revealed in a most vivid way the stream lines of the migrants across the sea and along the coasts to preferred departure points. This work has revealed the fallacy of the R.A.F.'s wartime comment that "only birds and fools fly—and birds do not fly by night", because the films show the tremendous upsurge in angel activity after sunset. In this connection and in association with Dr. Lack it has been pleasing to find in our films confirmatory evidence for the theory that swifts spend most of the night airborne—sleeping and waking!

By the use of time-lapse photography in association with the radar microscope device we have demonstrated that angel movements are not simple undirectional phenomena but complex counter diffusion effects; this work in fact shows that bird migration is a continuous multi-way movement which is occurring to some degree at all times. High power radar records of this type are now permitting a new approach to be made to the age old problem of how a migrant bird navigates. Space does not permit discussion of this problem but observations we have made on ring angels support the view that a bird flies with constant heading but with no correction for wind drift; the situation is not dissimilar to that obtaining in the aircraft case before the development of the Radar Doppler Ground Speed and Drift Indicator

RING ANGELS

A special type of angel formation was first recognized by Elder of University of Michigan in 1957 and was termed by him a "Ring Angel". An explanation for this phenomenon was sought in terms of sheer gravity waves in the atmosphere but Harper thought that a more likely explanation was by radar scattering from flocks of birds dispersing from a centre.

We have made many observations upon ring angels, a typical example of which is shown in Fig. 3. This consists of a series of concentric ring echoes which expand outwards from the ring centre, just as do ripples on a pond. The velocity of ring expansion is usually in the range 20 to 45 knots and the ring can achieve an overall diameter of as much as 20 miles.

The Bushy Hill records show that while ring angels may be observed on a single occasion only centred on various points within the cover of the radar, there are, on the other hand, a number of fixed points from which ring angels can take place throughout a substantial portion of the year. Such ring angels have only been observed in this country about sunrise.

Fig. 4 shows a plot of the ring angel sources which were observed during 1959. Armed with these map references and assisted by various Pest Control Officers we have been able to identify a large number of the ring angel centres with known starling roosts—including the special case of Trafalgar Square.

Using the Radar Microscope Display it has proved possible to record the arrival of the birds at the roost at sunset (Fig. 5) and to note the ring dispersal from this same point on the following morning at sunrise. Direct correlation between the emission of the successive rings from a ring angel centre and the eruption of starlings from the roost has been achieved by locating a number of observers at the roost. These engineers were equipped with V.H.F. radio which linked them to the radar

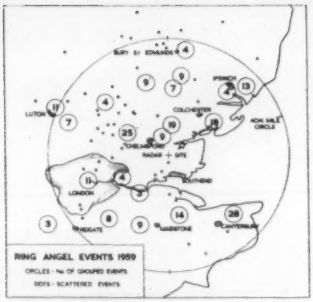

Fig. 4. *Distribution of Ring Angel Events, 1959.*

station. At the moment of bird eruption a signal was passed over the link and was impressed upon the film recording the P.P.I. picture; in this way perfect correlation between birds and radar rings was established.

The rings arise from the circumstance that the birds leave the roost in discrete flocks; they tend to fly from the roost along radial flight lines and since they are travelling at approximately the same speed they tend to assume the form of a ring. The rings often become displaced relative to each other because of wind sheer, but the circular form is still preserved and demonstrates that the birds are flying with a constant heading and apparently making no drift correction from their knowledge of the local topography. Dispersals from single night roosts are sometimes seen during the spring emigration period, but in this case the successive waves of birds proceed only in an easterly direction to join the general migrant stream.

The study of radar ring angels is providing a wealth of new information on the habits of starlings, methods of assembly and dispersal, roost occupancy, etc., which is not only significant to the ornithologist but may be of value in controlling a bird which can be at once both interesting and a nuisance.

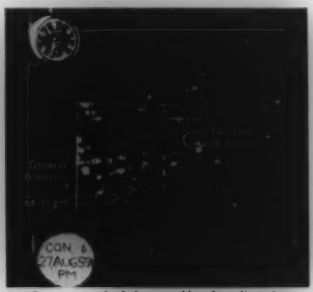

Fig. 5. *B-scope record of the assembly of starlings into a roost, August 27, 1959.*

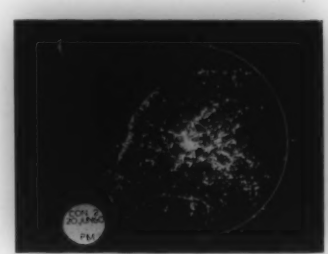

Fig. 6. *Line source of angels at a sea breeze front, June 20, 1960.*

LINE SOURCE OF ANGELS

Another configuration of angels which possesses special interest is shown in Fig. 6. In this case the angels are associated with a moving sea breeze front. The two portions of the front originated at the coasts of Essex and Sussex respectively in the early afternoon and moved across the country in a north westerly direction until their disappearance at sunset. The depth of penetration of the front and the continuity of the formation are in themselves remarkable and illustrate the use of radar in following the development of meteorological phenomena. The interesting question which now arises concerns the nature of the radio back scattering process at the front which renders it visible to the radar. Are we seeing scatter from a discontinuity of refractive index produced by the front or, as is also possible, are we seeing flocks of birds which are taking advantage of the front for soaring purposes ? The cine film clearly shows the angels streaming from the rear of the western front while the advancing southern front appears to have a scavanging action so that it sweeps up all the angels in its path.

MICROWAVE RADAR OBSERVATIONS ON THE AURORA

The polar aurora is a phenomenon of striking beauty which has always been regarded with awe and reverence by man. Nevertheless, it is only within the last fifty years that the classical investigations of Störmer and the studies of other workers have begun to unravel some of the mysteries of the aurora and to show the relationship between the aurora and the accompanying solar, ionospheric, and geomagnetic disturbances. Using simple visual and photographic techniques Störmer found that most aurorae occur at altitudes between 80 and 150 Km. and demonstrated that the ray structure closely follows the magnetic lines of force. The geographical distribution of the aurora was studied by a number of workers as were also the diurnal and yearly occurrences. The correlation of the auroral frequency with the sun spot cycle, also the obvious connection of certain intense aurorae with the transit of particular groups of sunspots across the sun's disc clearly pointed to some emission from the sun being the primary agent responsible for the auroral phenomenon. Following the famous demonstrations by Birkeland of the precipitation of cathode rays on a magnetized sphere Störmer traced the patterns that would be produced on the earth by the

incidence of a stream of charged particles emitted from the sun; in this way a fairly satisfactory explanation was given of the geometry of the aurora.

Radio range reflexion methods which have yielded such a wealth of information about the ionosphere were not applied to the aurora until after the war which, in fact, provided the radar high-power pulse-senders that were required in order to make such observations. These radio techniques have permitted daytime as well as night-time studies of the aurora and have provided much new information on the spatial and temporal distribution of the aurorae and of the connection between aurorae and other geophysical phenomena. In particular, it has been noticed that radio reflections from the aurora are obtained only in northerly directions; this observation has prompted careful investigation of the reflection process and this work has itself led inevitably to studies of the distribution of auroral ionization and the energies involved in the production processes.

Early attempts to observe radio reflexions from the aurora at microwave frequencies were not successful and so most of the radio studies have been conducted at frequencies between 20 and 500 Mc/sec. At these frequencies the beam width of the radar is usually in the order of a few degrees, and since there has been a tendency to employ long pulse-lengths in order to offset the comparatively low transmitter powers that have been available the consequent delineations of the auroral forms have necessarily been very rough and sometimes even misleading. The L-band equipment which has been used in the present experiments however, possesses a beam width of 0·7° only and this narrow beam in association with a pulse length of 5 μ secs and a power of 2 MW has permitted the recording of the aurora with the precision shown in Fig. 7.

Our first observation of the aurora on July 15, 1959, was in fact an accident since it had not been anticipated that auroral reflexion would be obtained at so high a frequency as 1300 Mc/s. The observation was made during the course of radar experiments directed to the study of angels but was of immediate importance in revealing that a particularly intense solar disturbance, as measured by the intensity of the subsequent magnetic storm, could produce a density of distribution of electrons within the lower E-layer capable of back scattering a 1300 Mc/s wave.

During the two years of observations with this equipment we have recorded three auroral events and on each of these occasions there has been direct correlation with a solar disturbance. Evidence of this disturbed state has also been provided by measurement on our radar of the noise received from the sun at a frequency of

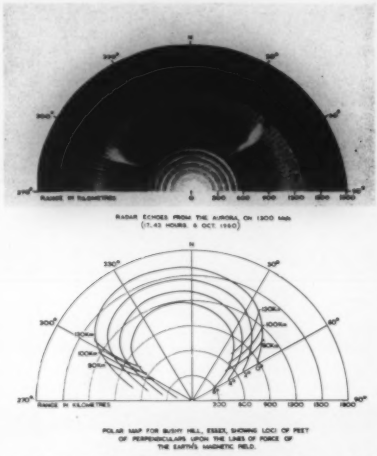
RADAR ECHOES FROM THE AURORA, ON 1300 Mc/s
(7.42 HOURS, 6 OCT 1960)
POLAR MAP FOR BUSHY HILL, ESSEX, SHOWING LOCI OF FEET
OF PERPENDICULARS, UPON THE LINES OF FORCE OF
THE EARTH'S MAGNETIC FIELD.

Fig. 7. *Radar Echoes from the Aurora on 1300 Mc/s with loci of specular reflection points from columns of field aligned ionization.*

1300 Mc/s. Survey of the magnetic records issued by the Eskdalemuir Observatory shows that in the 11 years from 1949 there have been 21 occasions when the disturbance in the H-field has exceeded 1000γ; if these events are listed in order of diminishing intensity, then the first six entries appear as shown in the table below.

It is clear from this table that only the more violent solar eruptions are likely to produce disturbances in the Earth's ionosphere of intensity sufficient to yield auroral echoes on a radar operating at so high a frequency as 1300 Mc/sec.

The various studies of the reflexion process which have been mentioned above have tended to suggest that radio energy is scattered from columns of ionization whose major axes lie along the lines of force of the earth's magnetic field. The precision of the auroral record shown in Fig. 1 allows this theory of radio reflexion from field aligned regions of electron concentration to be tested and the stringency of the specular reflection condition assessed in the case of a wavelength of 23 cms.

Order	*Year*	*Date*	*H-disturbance* (γ)	*Radar aurora* (1,300 *Mc/s*)	*Duration*
1	1959	July 15	4,103	Observed	15.50—17.15 U.T.
2	1958	February 11	2,762	Equipment not in use	—
3	1960	April 1	2,592	Observed	14.00—17.15 U.T.
4	1957	January 22	2,340	Equipment not in use	—
5	1957	September 4	2,300	Equipment not in use	—
6	1960	October 6	2,280	Observed	16.50—18.25 U.T.

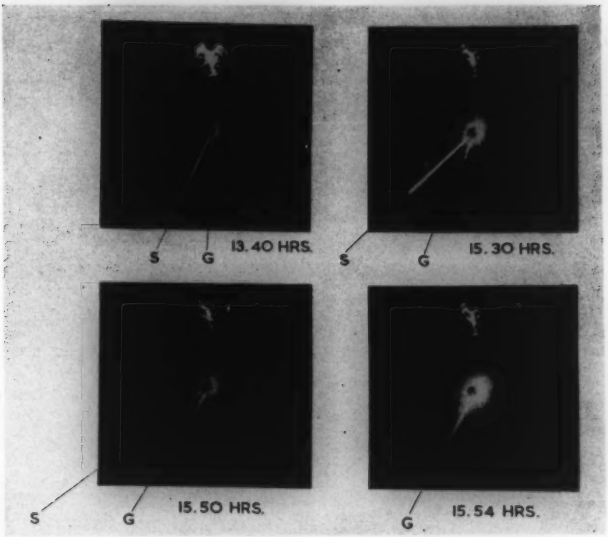

Fig. 8. *Solar and Galactic Noise at 215 Mc/s.*

The lower portion of Fig. 7 presents the polar map which has been calculated for our radar site at Bushy Hill in Essex and shows the loci of the feet of the perpendiculars on the lines of force of the earth's magnetic field for a given angle of elevation of the rays from the radar. The magnetic data from which these curves have been derived was taken from the Admiralty Charts of Isogonics and Isoclinics. Also included in Fig. 7 are the curves of constant height corrected for atmospheric refraction. Comparison of these curves with the auroral record leads to the conclusion that departure from the 90° reflexion condition is less than $\pm\frac{1}{2}°$, and that the region of the ionosphere where the auroral reflections take place is of the order of 20 Km thick, the mean height being 90 Km. This value is somewhat lower than that suggested by workers operating at much lower radio frequencies; it is likely, however, that this difference is not only real but possesses significance in the interpretation of the distribution of ionization that follows a solar disturbance so extreme as to yield an aurora visible at microwave frequencies.

These microwave auroral records have been made by the method of time-lapse photography of the P.P.I.; it is certain that detailed analysis of these films will yield valuable information on the dynamics and electron densities of the scattering regions.

RADIO MOONSHINE

The spectacular results which have been obtained in recent years in radio astronomy have been obtained with passive receiving systems in which aerial gain and receiver noise figure have been the vital parameters. Improvements in these same radar parameters have also been obtained in civil and military radars as has been indicated above. In particular, it is now commonplace for a microwave radar to paint the noise from the sun even when the sun is in its normal quiescent state. We do in fact make use of this type of observation in checking the azimuthal and elevation accuracy of radar installations.

Similarly, observations on the sun are also possible with a metric radar and Fig. 8 shows a sequence of P.P.I. records obtained with a radar operating at 215 Mc/s. The signal marked " S " is that received from the sun and the diurnal motion will be apparent. The signal marked " G " is a similar but much weaker noise signal which also shows diurnal motion but slightly different from that of the sun; a few days of observation showed that the movement " G " corresponds to siderial time and that this signal was produced by noise from the galazy.

An observation made on the afternoon of October 27, 1955, showed that the sun's radiation was greatly enhanced in that the solar noise signal expanded in azimuth to fill 90° of the tube face. The disturbed state of the sun was later confirmed from the usual sources. For a brief time during the period 15.20 to 16.00 hrs. of this day a noise signal was observed to paint upon the P.P.I. along a south-easterly bearing.

This signal was very faint indeed but persisted over about 20 sweeps of the aerial (5 minutes). Preoccupation with a test flight prevented careful observation of this noise signal except to make a rough tracing on paper of its position relative to the angular centre of the sun's signal. Visual observation of the moon on conclusion of the flight showed it to be in the same general direction as had been noted for the strange noise signal and so the possibility was recognized that this signal might result from reflection from the moon of the enhanced noise radiation from the sun, i.e. that " radio moonshine " on 215 Mc/s had been observed.

Measurement of the above tracing returned an angle of 134° for the angular position of the unknown signal relative to the sun's bearing. Extraction of the corresponding angle for the moon from the Nautical Almanack for the time in question gave 135°. This was rather exciting agreement having regard to the crudeness of the tracing and the difficulty of estimating the axis of the solar signal upon the P.P.I.; it remained to test whether the path attenuations were compatible with the " Radio Moonshine " Theory.

From a knowledge of the polar diagram of the aerial system and the respective intensities of the solar and lunar signals it could be established that the moon signal as presented to the antenna could have been in the order of 54 dbs down on the solar signal. The intensity of the solar flux presented to the moon at any instant is essentially equal to that obtaining at the earth and so the attenuation produced by the moon reflection appears as 10 log $\sigma/4\pi r^2$ db, where σ is the echoing area of the moon from the earth.

Taking the presently accepted value of σ as $0{\cdot}1\ r^2$ leads to a path attenuation of 62 dbs which exceeds the above estimated signal ratio by 8 dbs. Under these circumstances the moon could have yielded a reflected signal detectable on the P.P.I. only during a burst of solar noise above the enhanced level. Such short duration bursts do indeed occur.

Taking the evidence as a whole, viz. correct bearing of the moon, enhanced sun, freedom of the site from spurious reflections, and finally the polar diagram effects, it appears likely that the noise signal of unknown origin observed on October 17, 1955, by this 215 Mc/s radar was indeed due to reflection by the moon of the noise radiated by the sun during a solar eruption. This evidence for the observation of radio moonshine is certainly not conclusive although much superior to that by Steinberg and Zisler in 1949 who claim confirmation of a lunar reflection even though the noise signal was only 18 dbs down from that of the sun. " Radio Moonshine " is indeed difficult to detect and measure—perhaps this work will help to make a future identification of moon reflections more certain by concentrating attention on observations made during solar bursts.

I would like to thank my colleagues of the Propagation, Radar and Photographic Sections of the Great Baddow Laboratory whose co-operation has rendered this work possible.

Appeal for the Physics Trust Fund

The following donations or subscriptions were received between May 24 and June 23, 1961:

(*a*) From Members

Professor L. C. Biedenharn
Dr. J. B. Birks
Dr. R. W. Cahn
Dr. R. Huby
Mr. W. Harold Jones
Mr. F. A. Long
Mr. W. W. Mason
Mr. K. Wilkins

(*b*) From firms

G. Cusson Ltd.
Lansing Bagnall Ltd.

July 1961

Education in the U.S.S.R. with Particular Reference to Physics

J. L. LEWIS, M.A.
Senior Science Master, Malvern College

INTRODUCTION

WHEREAS it is impossible to generalize about education in America or Great Britain, because of the wide standards and variations in those countries, it is much easier to do so about education in the U.S.S.R. because of the similar organization and similar standards throughout the whole of the Union. There are variations from republic to republic, but the general pattern is everywhere the same. This article will be concerned mainly with physics teaching as that is the aspect of education the author went to see, though it will necessarily include reference to the general system of education.

Those who have already commented on physics teaching in the U.S.S.R. were either university people who had gone primarily to study the research being done or educationalists, who had gone to study education in general and were not particularly interested in physics rather than any other subject. It is hoped therefore that this article will include something of value.

It should be emphasized in this introduction that I am quite the reverse of being "starry-eyed" about the Communist system. I have certainly not returned a disciple and would hate to live or to work under their system. None the less I returned very impressed indeed by the organization of their physics teaching and the standards being achieved. We ought to be aware of what is going on and I am quite convinced, as I hope this article will show, that we have much to learn from them.

ORGANIZATION OF SCHOOLS

Ministerial responsibility for schools

Whereas university teaching comes under the Ministry of Higher Education of the U.S.S.R., all school teaching comes under the separate Ministries of Education of the various republics. During my visit, I was in both the Russian and the Ukrainian Republics and was consequently able to compare the two: the syllabuses and the organization were very similar indeed. There is close liaison between each republic and I was informed I would find the same similarities in the other republics.

There is, however, far less liaison between the universities and the schools, primarily because they come under different ministries. I encountered repeated criticism of this both from the Deans of the faculties visited and from university professors of physics. They were impressed that the Physics Panel of the Science Masters Association, which was responsible for the new physics syllabus, included university representatives. This apparently never happens in the U.S.S.R. and was deplored.

The types of schools

Education is compulsory for the eleven years from 7 to 18* and the same types of school for this age group will be found throughout the U.S.S.R. All children have the same basic education for the first eight years: this is done either in an 8-year school or in the first eight years of an 11-year school. On completion of the eight year course, the final three years can be completed in an 11-year school, in a tekhnikum or in a Labour Reserve School. There are thus the following types of school:

(*a*) Basic 8-year school for children aged 7-15.

(*b*) The 11-year school for children aged 7-18, consisting of the basic 8-year education with three additional years of academic study, which could lead to the universities.

(*c*) Separate schools offering the 9th-11th grade course for pupils aged 15-18, who have completed the basic 8 years at an 8-year school and wish to continue with the rest of the 11-year academic course.

(*d*) The tekhnikums, providing a vocational training for pupils who have completed their basic 8-years. The education is still general, but there is a vocational bias. The tekhnikums can also be attended by pupils who have completed an 11-year course, but who are not going to a university or other institute of higher learning. They do a shortened version of the course arranged for the younger intake.

(*e*) Labour Reserve Schools. For the less able pupils who have completed their basic eight years. They provide part time education, part time industrial or agricultural work.

Throughout the above I have referred to 8-year and 11-year schools. Until recently these schools were 7-year and 10-year schools, but as a consequence of Mr. Khrushchev's Memorandum to the Praesidium in 1958 on Education, referred to below, these are now being extended to 8-year and 11-year schools. By the end of 1962, the transition will be complete and there will be only 8-year and 11-year schools. Throughout this report therefore reference will only be made to the new system.

General comments on Soviet schools

In the last 40 years there have been several changes of opinion over co-education. At the present time the basic schools are almost invariably mixed, the teaching staff likewise consisting of men and women with a predominance of women.

By law classes may not exceed 30 pupils. Only once did I see a class of 26, they were usually classes of 24 at all levels. This compares most favourably with the English system.

* Until recently only compulsory for 8 years, but the intention was to make it available for all for the full 11 years by the beginning of 1961 and this seems to have been widely realized.

A teacher does not normally teach more than 24 periods a week. The pupils do 24 initially, rising eventually to 33 or 34 periods a week towards the end of their time at school.

The universities and tekhnikums are usually residential or partially residential. One of the most interesting features is the large and increasing number of boarding schools and these are discussed in detail below.

The shortage of school accommodation was very acute after the end of the war and this led to a certain amount of staggering: one group of children using the school buildings until 2 p.m., a further group from 2 p.m. onwards. A very few of the day schools still have this shift system, but it has been condemned by Mr. Khrushchev and the number is decreasing rapidly as new buildings are put up. This shift system incidentally did not mean that teachers did double the teaching, there would be a completely different teaching staff for each shift. However the system will soon be a thing of the past.

A feature of the Soviet schools that is particularly strange to English ideas is that the pupils must go steadily through the school course, year at a time, without any streaming. A boy cannot therefore "get ahead" however good in some subjects. It was argued that they do not wish to produce a boy brilliant only at mathematics, but a boy who has received a properly rounded education: if a boy is good at one subject, he is probably not so good at others. The stronger pupils can always help the weaker and mutual help is very much encouraged. Russian teachers visiting England recently deplored our system of putting weaker children into lower forms; they argued that this must have "disastrous psychological effects". The shadow of Lysenko lies across the whole Soviet educational system. Believing that environment is the dominant influence in development, they will not accept that there is a dull child. Failure is as much a reflection on the teacher and the school as on the pupil.

The boarding schools

One of the most interesting educational features of the last four years is the enthusiasm for Internats and I visited both those giving the basic 8-year course and those giving the 11-year course. The first boarding school is only four years old, but 135 are planned in Moscow alone during the present five-year plan and 70 have already been opened. The same enthusiasm for them was found in the Ukrainian as well as the Russian Republic and apparently the same is the case throughout the whole of the U.S.S.R. The schools are virtually free, a purely nominal sum being paid for the food and accommodation provided.

I visited a number of these schools in both republics and was most impressed by them. There was evidence that they recruited very good teachers and it seemed that standards were particularly high in them. As in all Soviet schools the pupils wear a school uniform, but it was noticeable how much more neatly dressed they tended to be in the boarding schools. There was plenty of evidence of education in its broadest sense with flourishing art departments, dramatic societies, musical activities, workshops and the like: the one omission being anywhere comfortable to relax and do nothing, but that seems a feature of all life in the Soviet Union. The physics in these schools was certainly good. I gained the impression they were good all round. The children seemed very happy and uninhibited.

Whenever I asked where Russians were sending their own children, the answer was repeatedly that they had entered them for an Internat, but were afraid they had not or would not get a place. The mother would explain that she worked during the day, was tired when she got home and not in a state to answer her child's questions. She would much prefer her children to go to a boarding school where there was someone trained to answer their questions, who could look after the children properly all the day long. She would see her child at the week-end and a lot of the internats are in fact weekly boarding schools.

These references to the difficulty of getting admission led me to probe how pupils were selected. I asked the same questions at each internat and always had the same replies: the schools were stated to be open to all, it was hotly denied that they were schools for an elite, admission was decided by a committee who considered each case on its merits, a child who had lost one or both of its parents had a good chance of a place, but in the end it was finally admitted that places often went to children of politicians, diplomats, surgeons, theatrical people or ballet dancers as "they were very busy people". Despite the denials, I gained the impression very strongly that these were indeed schools for the elite and these answers confirmed it.

The Tekhnikums

The tekhnikums aim to provide a technical training, their intake coming mainly from 8-year schools, but also from 11-year schools. A typical institution was the Electromechanical Tekhnikum for Railway Workers visited in Kiev. This had 1,000 students, of whom 600 were resident in the hostel attached. Those coming from an 8-year school did a 4 year 4 month course, those from an 11-year school a 2 year 9 month course.

There is obviously a very technical bias, but general subjects are still continued, the curriculum including Principles of Marxism-Leninism, Political Economy, Russian literature and a foreign language. The physics course was a very general one and not restricted to the limited field associated with the particular technology concerned. In all the institutions visited, apparatus and equipment were always most plentiful. In the tekhnikum mentioned above, there was a considerable profusion of demonstration models and exhibition equipment made by the students themselves and used in the teaching; there seemed no objection to tying up large numbers of very expensive meters in this equipment.

KHRUSHCHEV'S MEMORANDUM ON EDUCATION AND ITS CONSEQUENCES

On September 21, 1958, Mr. Khrushchev addressed a memorandum to the Praesidium on Education. In this he criticized the existing educational system, saying that the schools needed to be brought much closer to life. He claimed that "at present our 10-year secondary schools are not solving the task of preparing

our young people for life, but are training them only for entering higher educational establishments ". Only a proportion of those at a 10-year school go to a university: 450,000 per annum go on to higher establishments, 800,000 do not. The whole structure of the system was too academic. It was also necessary to inculcate a greater respect for physical work.

This call for a less academic approach in order to relate education to Life has had wide consequences. The 7-year and 10-year schools have become 8-year and 11-year schools respectively. More time has been devoted to physics, for as stated elsewhere " Physics is Life ". More attention has been paid to workshops. Most 11-year schools are now associated with an industrial factory, the pupils spending at least a little time each week in the factory. A typical example was the 11-year school in Kiev associated with a radio valve factory, where the pupils spent eight hours each week. A consequence was that of the 67 pupils graduating from that school last year, 20 went to the university, 40 were ready and able to go straight into work in the factory and seven went to other enterprises.

The influence Khrushchev's memorandum has had on physics teaching is obvious. It has stimulated interest in the subject and encouraged the production of more and better demonstration apparatus, it has encouraged the production of films which not only stimulate the teaching, but also relate the academic work to the world outside.

It has however had subtler influences as well. The teaching of languages has ceased to be the academic process it once was. I attended a most lively English class for nine year olds and not a single word of Russian was spoken the whole lesson: I was able to converse with the children, though it had to be in the present tense and I had to avoid adjectives.

The memorandum does seem to have produced some remarkable results extraordinarily rapidly.

SLOGANS AND THE ATTITUDE TO WORK

I cannot conclude these general remarks on education and schools without some reference to the slogans which abound. The influence of slogans in the every day life of the Soviet citizen seems to be considerable, but nowhere was it more noticeable than in educational establishments. As these slogans seem to typify the whole attitude to work and study, I felt I must devote a section to them and to two slogans in particular.

Leninism is studied by all students at school and university, pictures of him abound everywhere, certainly one in each classroom, and there is always a Lenin " shrine " in each school. Various of his sayings are displayed on the walls as slogans, but one above all appears everywhere and in greater profusion than all the others:

" work, work and work ", V. I. Lenin.

It appears everywhere in Russian, but also in English in the English Room, in French in the French Room and so on.

This slogan typifies the whole attitude to work in all the schools I visited: work was something that really mattered, study was not just a weariness of the flesh. One's whole future and the future of one's country depended on the work one did. Such intensity was frightening. The place that sport plays in some English schools was quite incomprehensible to them if it could ever interfere in any way with work.

The second slogan that was repeated to me with regularity was:

" Physics is Life ".

In modern life everyone is closely associated with physics. In universities, whatever one's specialization, over 80% were concerned with physics in some form. It was the subject that mattered and the backbone of all the technologies. Again and again different people would say " . . . but Physics is Life ". And Mr. Khrushchev has told them that their education must be more closely related to life.

THE CURRICULUM AND ORGANIZATION OF ACADEMIC WORK IN SCHOOLS

The Ministries in the respective republics are responsible for the curricula and there are therefore slight differences from republic to republic. The details of the syllabuses, the textbooks, the scientific apparatus and the visual aids are worked out and decided by the Academy of Pedagogical Science in that Republic.

The curriculum is exactly the same for everyone in both the 8-year and the 11-year schools: there is no specialization. Science plays an important part, but in no sense is the education narrowly scientific, in fact it is a much broader education at all stages right up to the end of a university course than is the case in England.

For the first three years at school there is a concentration on Russian language, Russian literature and mathematics with some singing, handwork, drawing and physical education. Then history, geography, biology and a foreign language are started. In the sixth grade, physics is introduced; in the seventh grade chemistry. Towards the end of the course, the Principles of Marxism-Leninism, the Constitution of the U.S.S.R. and astronomy are added to the curriculum as well as a number of periods in the school handicraft rooms and workshops (all schools seemed to have their quota of metal lathes, etc., and some good work was produced both in metal and wood).

Though biology is the first science to be introduced and is clearly important in the 8-year course, it ceases to be so significant in the 9th-11th grade. Chemistry starts later than physics and has fewer periods devoted to it. The number of hours per week is as follows:

Grade	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*Total at end of 8 years*	*9*	*10*	*11*	*Final total*
Biology	—	—	—	2	2	2	2	3	11	2	1	—	14
Physics	—	—	—	—	—	2	2	3	7	3	4	5	19
Chemistry ...	—	—	—	—	—	—	2	2	4	2	3	3	12
Mathematics ...	6	6	6	6	6	6	6	6	48	6	6	6	66

PHYSICS IN SCHOOLS

The physics syllabus for schools

The physics syllabus in the Russian Republic is prepared by its Academy of Pedogogical Science, final ratification coming from the Russian Ministry of Education. There are differences from one republic to another, but as the Pedagogical Institutes in the other republics keep in close touch with the Russian Academy of Pedagogical Science in Moscow the differences are mainly ones of detail rather than of principle.

Not only is the Academy responsible for the Russian physics syllabus, but also for the textbooks to be issued in its republic, for the demonstration equipment, the laboratory work to be done by the pupils themselves and for visual aids. In fact they provide a course complete in itself. As explained elsewhere in this report, their intention is to enable the indifferent teacher to teach well as there will never be as many really good teachers as are needed.

The syllabus therefore includes not only a list of topics to be discussed, but also a list of the demonstrations to be shown to the pupil, a list of the experiments to be done by the pupil himself, the films to be shown to him and finally a list of expeditions and factories to be visited in order to relate his physics to the outside world. This organization was exciting.

It was repeatedly emphasized that the syllabus only laid down the minimum requirements and the teacher was at liberty to develop his own ideas and was encouraged to do so. It was not intended to stultify him, but merely to ensure that the teaching achieved a certain minimum standard of efficiency.

The journal *Physics in School*, which is the Russian equivalent of the British *School Science Review* testifies to the liveliness of their teachers: new techniques are discussed, new experiments suggested and details given of apparatus that can be made. There is no suggestion here, nor was it evident in any school visited, that the teaching is rigid because of the detailed syllabus. On the other hand there was much evidence that it did ensure that all children were adequately taught, even by less experienced teachers, without at the same time stultifying the good teachers with ideas of their own.

I have given an abbreviated summary of the syllabus in the next section in order to show the topics involved and the weight given to each.

The content of the physics syllabus

The syllabus given here is an abbreviated version of that in use in the Ukrainian Republic for all their 8-year and 11-year schools. It is included here to show the topics studied and against each is given the number of hours it should occupy. It was emphasized that this was not something rigidly to be adhered to, but an indication to the teacher in order to guide him.

Time has not been included here for tests and examinations for practical work and for revision.

The final section in the 11th grade on Atomic Structure and Nuclear Energy has been given in rather greater detail than the other sections as this work is less conventional. In the full syllabus each section is expanded in the fullest detail.

6th GRADE (70 hours)

Introductory

	Introduction to Physics	2
1.	Methods of measurement	5
2.	Force and mass	6
3.	Density...	5
4.	Pressure	3
5.	Properties of solids	5
6.	Properties of liquids	15
7.	Properties of gases	9
8.	Kinematics	5
9.	Inertia. Elementary mechanics	6

7th GRADE (70 hours)

Mechanics

1.	Composition of forces...	8
2.	Work. Energy	15
3.	Energy of motion	4
4.	Sound	5

Heat

1.	Basic knowledge of molecular structure of substances	3
2.	Expansion	3
3.	Heat transmission	4
4.	Measurement of heat	6
5.	Change of state	6
6.	Heat engines	8

8th GRADE (105 hours)

Electricity

1.	Basic knowledge	3
2.	Currents	8
3.	Current, voltage and resistance	14
4.	Heating and other effects	9
5.	Electromagnetic phenomena...	9
6.	Action of magnetic fields on current carrying conductors	5
7.	Electromagnetic induction	8
8.	Radio communication	6

Optics

1.	Rectilinear propagation of light	3
2.	Reflection and refraction	8
3.	Optical instruments	6
4.	White light. Colours. Spectra	3
5.	Photoelectric effect	2
6.	Atomic structure	6
	Evidence of atomic structure	
	Radioactivity	
	Nuclear model	
	Protons and neutrons	
	Energy from the nucleus	
	Uses of nuclear energy	

9th GRADE (140 hours)

Mechanics

	Introduction	1
1.	Motion. Kinematics	11
2.	Newton's laws of motion	16
3.	Curved and circular motion	14
4.	Gravitation	4
5.	Work and energy	8
6.	Elements of statics	10
7.	Mechanical vibrations and waves	16
8.	Motion of liquids and gases	9
	Theory of flight	

Molecular Physics and Heat—I

1.	Basis of kinetic theory of matter	3
2.	Internal energy, heat and work	8
3.	Properties of solids	10
4.	Properties of liquids	4
5.	Properties of gases	10

10th GRADE (123 + 36 hours)

Molecular Physics and Heat—II

6.	Change of state	12
7.	Heat engines	11

Electricity

1.	Electric charge. Electric field	15
2.	Electricity in metals	13
3.	Electricity in gases and in vacuo	8
4.	Electricity in liquids	5
5.	Semiconductors	4
6.	Magnetic fields and electromagnetic induction	12
7.	Alternating current	14
8.	Electromagnetic vibrations and electromagnetic waves	13

Astronomy (36 hours)

11th GRADE

Optics

1.	Dispersion of light. Photometry	5
2.	Reflection and refraction. Optical instruments	14
3.	Wave properties of light. Sources of light	12
4.	Interaction of light and matter	6

Atomic Structure and Nuclear Energy

1. Atomic structure
   - Natural radioactivity
   - Half life
   - Methods of detection
   - Counting techniques
   - Wilson cloud chamber
   - Atomic structure. Nuclear model
   - Energy relationships
   - Artificial radioactivity
   - Protons and neutrons
   - Nuclear energy. Relationship between mass and energy
   - Transformation of nuclei
   - Energy released in nuclear reactions
   - Basic cosmic rays
2. Uses of nuclear energy for peaceful purposes
   - Nuclear reactor
   - Nuclear power station
   - Accelerators and accelerated particles
   - Uses of tracers for industry, medicine, agriculture and other branches of science and technology

Comments on the syllabus

It should be noted that the syllabus includes the physics of flight, supersonics, 3-phase electricity, photoelectric effect, a study of the nucleus and nuclear transformations, fission and chain reactions, semiconductors.

It does not include interference phenomena, the Doppler effect, kinetic theory, moments of inertia, surface tension, viscosity, elasticity, simple magnets. There is no mathematical treatment of lens formulae or achromatism, in fact the work on optics is drastically reduced. None of the syllabus requires any calculus or co-ordinate geometry, which are not studied in schools.

When studying this syllabus and comparing it with the English Advanced-level syllabus, with which it has much in common, it must be remembered that this syllabus is studied by every child in the U.S.S.R. as far as the 8th grade, and then by every child in an 11-year school for the last three grades. It is done by everyone, not just specialists in physics as in England.

General comments on physics teaching

(1) The teachers

Though there are sufficient teachers for the schools, I was repeatedly told there were not enough really good natural teachers. They accept that this will always be the case and set out to ensure that the indifferent teacher has sufficient guidance and sufficient material (apparatus, films, etc.) to ensure that he gives a good lesson. I saw a very large number of physics lessons: there were some first-class teachers who gave brilliant lessons and also a large number of indifferent teachers, uninspiring men with a dull delivery. Despite this I never saw a single dull or uninteresting lesson during my entire visit. This is certainly something we could never claim in England. The interest was maintained by the demonstrations and other aids to teaching irrespective of the quality of the teacher.

(2) A typical lesson

In order to elaborate the point above I quote a typical lesson: a lesson on the Hydraulic Press given to a class of nineteen 13-year old boys and girls in the 6th grade of a typical Moscow 11-year school by an indifferent teacher as far as personality was concerned.

The lesson began with five minutes of revision of what had gone before, question and answer around the room on pressure due to liquids. When it was apparent that they remembered and understood the previous lesson, the teacher wrote the lesson topic on the board—The Hydraulic Press. The blinds were immediately drawn, he pressed a button and there was a five-minute film of animated diagram on the hydraulic press. The pupils, interest was clearly aroused. Lights up and the teacher drew a diagram of the hydraulic press on the board, discussing all the while the various parts and their significance with the form. When complete and the details were understood, he produced a model hydraulic press from under his demonstration bench. He discussed the various parts, what happens here, where does the oil go in ? He did an experiment breaking a hole in a metal sheet. What were the forces involved ? What force was I exerting on the lever here ? A general discussion with the form taking a full part. Let us do a calculation. A return to the blackboard: suppose the area here is so much and here so much, if I exert a force of 3 lbs here what is the force here ? The pupils spend a few minutes on it. One comes to the front to do it on the board (a common technique this). Not all have got it right, so they do another.

This time success. Put down the diagram in your

notebook and write a brief note on it. About 35 minutes have now gone. The blinds are drawn again, the button pressed and the projector at the back of the room continues with the film showing hydraulic presses in use in industry. Lights up. Three minutes left. To-night's homework, read pages 81, 82 and 83 in the textbook and do examples 1 and 2 on page 84.

An indifferent teacher but an extremely interesting lesson, made possible with the right aids. It was a lesson full of great variety so the interest of the pupil was maintained the entire time. One sensed at the end that they had really learnt something about the hydraulic press and that the subject would not have to be gone through again and again.

(3) The films

There were repeated apologies for the quality of the films. "Those are all we have at the moment, but come back and see what we are to produce in the next five years". By some standards the quality was poor, there was no technicolour, no beautiful scenic shots, no background music, but every film I saw was directly related to the teaching and exactly what one needed to get the subject across to the pupil. In the Ukrainian Republic there were 150 pre-O-level films, in the Russian Republic 144, which must necessarily be shown to the pupils. Most of them were short, but all were pertinent to the subject. We have almost no such films.

(4) The apparatus

At the level of research work in universities and institutes, I have heard very critical comments on the quality of the apparatus. But in teaching, precision instruments are not required and the apparatus seemed first class for precisely what it was intended to do.

The political system lends itself very well to the provision of apparatus in schools. The Physics Department of the Academy of Pedagogical Science decides an oscilloscope is needed in schools, thought is given to the experiments it may be required to do, research is done on the right kind of instrument to do these, prototypes are tested in a limited number of schools, a decision is taken, an order is placed with industry for ten thousand and every school gets an oscilloscope. Above all it is the right oscilloscope to do the job required of it.

The Academy of Pedagogical Sciences has worked out the apparatus necessary for the physics course and no new school opens until it is completely equipped with the basic apparatus.

(5) Experimental work by the pupils

The experimental work done by the pupils themselves shows similarity to the English system. Certainly a lot more experimental work is done than in some European countries. All schools have a physics laboratory, fully serviced.

The syllabus prescribes certain compulsory laboratory experiments, a list which tends to increase from year to year. In the 6th, 7th, 8th and 9th grades, equipment is available so that every pupil does the same experiment at the same time. In the 10th and 11th grades, a schedule of experiments is made out by the schools for their pupils: there are usually three sets of apparatus for each experiment and the pupils work in pairs.

(6) Laboratory Assistants

Each school visited both in Russia and in the Ukraine had at least one assistant in the physics department. He got out the demonstration apparatus, looked after the laboratories, repaired and made apparatus, looked after the films and film projector. They were usually young assistants who did the work part time when they were also studying for some technical exam.

(7) Examinations

The system varies a little from republic to republic. In general formal examinations are held once a year in the spring. In physics they are almost always oral examinations the pupil having up to half an hour before a board of examiners, which always included his own teacher. In the Ukraine, the board consists of only two people. If a pupil fails he may try again in the autumn: failure then would mean repeating the whole year's work.

UNIVERSITY PHYSICS

It was not my business to look at research work in university physics departments: my concern was with the general organization and teaching of the basic physics course. I visited the physics departments of both Moscow State University and Kiev University. There were close similarities in organization between the two.

Entry to the University

The sources of students are (*a*) the 11-year schools, (*b*) the tekhnikums. At one time students who had won gold or silver medals in their State maturity examination (the school leaving examination) could automatically enter the university. This has been discontinued and everyone must now take the State University entrance examination.

This is held in seven subjects, a candidate usually taking three to five depending on his proposed course: the standard is approaching that of the English A-level examination. The subjects are:

(1) Russian language and literature—compulsory for all.
(2) Mathematics
(3) Physics
(4) Chemistry
(5) History
(6) Geography
(7) Modern Language—choice of English, German, Chinese or French.

For physics, a candidate must take 1, 2, 3, 4, 7, five subjects in all.

University physics courses

The length of a university physics course is 5½ years, that is 11 semesters with two months holiday each summer and 2 weeks in the winter. The length of the course is the same as for engineering, though longer than that for chemistry and mathematics. Examinations occupy the whole of June each year and the course includes two months of practical work in industry. The end of the course is always devoted to a diploma project.

The course is a very general one, a foreign language for example being a compulsory part of it. In no sense

is it a narrow course as the details given below will show. One incidental but interesting feature found in the Ukrainian Republic was that each physics student is obliged to give two physics lessons at a secondary school, partly to make him aware of the difficulties of teaching, partly to interest him in the profession.

It will be seen that the first 2½ years is devoted to a basic course. Then the student will start to specialize in one particular field though at the same time continuing with his general studies. In the middle of his fourth year he will start practical work in his specialist field, usually working in the university's research laboratories. This leads on to his diploma work which occupies most of his last twelve months. The system claims that the student is ready trained to take his full part in a university or industrial research laboratory on completion of his course and does not have to undergo a further period of training as is usually necessary with the English graduate: the Russian graduate can make a contribution straight away.

The physics curriculum in Moscow University is as shown below.

In Moscow State University there are nine departments in the Faculty of Physics and a student will chose one of these for his specialization. The chairs in the various departments are as follows:

1. Theoretical and mathematical physics
   - Professor of mathematics
   - Professor of electrodynamics and quantum theory
2. Nuclear physics
   - Professor of atomic nucleus
   - Professor of nuclear spectroscopy
   - Professor of accelerators
   - Professor of cosmic rays
   - Professor of radioactive radiation

Physics Curriculum in Moscow University

Subject	*Year*	*I*		*II*		*III*		*IV*		*V*		*VI*
	Semester	1	2	3	4	5	6	7	8	9	10	11
Hours per week												
BASIC COURSE COMMON TO ALL												
1. Principles of Marxism-Leninism		3	3	4	4	—	—	—	—	—	—	
2. Political economy		—	—	—	—	2	3	2	2	—	—	
3. Dialectical and historical materialism ...		—	—	—	—	—	—	2	3	5	—	
4. Foreign language		4	4	4	4	—	—	—	—	—	—	
5. History of physics		—	—	—	—	—	—	—	—	4	—	
6. Chemistry		4	2	—	—	—	—	—	—	—	—	
7. Higher mathematics		10	10	10	6	—	—	—	—	—	—	
8. Drawing		2	2	—	—	—	—	—	—	—	—	
9. Workshop instruction		2	2	—	—	—	—	—	—	—	—	
10. Physical education and sport		2	2	2	2	—	—	—	—	—	—	
11. General physics		4	6	6	6	—	—	—	—	—	—	
12. Practical course in general physics ...		5	5	6	6	—	—	—	—	—	—	
13. Methods of mathematical physics ...		—	—	—	—	8	7	—	—	—	—	
14. Practical mathematics		—	—	—	—	1	1	—	—	—	—	
15. Atomic physics		—	—	—	—	3	2	—	—	—	—	
16. Nuclear physics		—	—	—	—	—	3	3	—	—	—	
17. Theoretical mechanics		—	—	—	4	5	—	—	—	—	—	
18. Thermodynamics and statistical physics		—	—	—	—	—	2	4	—	—	—	
19. Electrodynamics		—	—	—	—	4	4	—	—	—	—	
20. Quantum mechanics		—	—	—	—	—	—	4	4	—	—	
21. Principles of radio		—	—	—	—	3	—	—	—	—	—	
22. Special practical course in atomic, nuclear and radio physics		—	—	—	—	6	6	9	9	—	—	
SPECIALIZED WORK												
23. Specialization subject		—	—	—	—	—	4	6	6	6	6	
24. Laboratory work in special subject ...		—	—	—	—	—	—	—	7	14	22	
Totals ...		36	36	32	32	32	32	30	31	29	28	

Theoretical instruction	162 weeks
Exam. sessions	35 weeks
Industrial practical work	8 weeks
Diploma project	21 weeks
Vacations	55 weeks

The 11th semester is devoted entirely to the diploma project.

Professor of nuclear physics and electronic phenomena

3. Radio physics
   - Professor of oscillations
   - Professor of radio technique
   - Professor of electronics
   - Professor of acoustics
   - Professor of radiation and canalization of electromagnetic waves.
4. Physics of solids
   - Professor of the physics of solids
   - Professor of the physics of semi-conductors
   - Professor of magnetism
   - Professor of the physics of crystals
5. Molecular physics
   - Professor of molecular physics
6. Optics and spectroscopy
   - Professor of optics
7. Geophysics
   - Professor of the physics of the earth-crust
   - Professor of the physics of sea and land
   - Professor of the physics of the atmosphere
8. Low temperature physics
   - Professor of low temperature physics
9. Astronomy
   - Professor of astrophysics
   - Professor of astrometry
   - Professor of stellar astronomy
   - Professor of celestial mechanics and gravimetry

Typical diploma projects include work on quantum theory of metals, ferromagnetism, relativity, computational techniques, theory of fundamental particles, crystallography, electronics, low temperature techniques, acoustics or geophysics.

Miscellaneous comments on university physics courses

In Moscow State University the annual intake of physics students is 450 per annum. There are high demands made for the entrants and these high demands are maintained throughout the course. Between 50 and 60% of the students live in hostel accommodation.

As in school teaching considerable thought is given to demonstration apparatus. For the basic physics course, a special printed book of demonstration experiments is published for Moscow University and includes 1374 basic demonstrations readily available for lecturers. These are all large scale demonstrations to suit the numbers involved. The list is impressive.

Practical work in the basic physics course is also elaborately organized as it must necessarily be with so many students. There seemed no shortage of elaborate equipment.

Three months before the student graduates a decision is taken about his future. Almost invariably he will continue in the field in which he has specialized. Of 423 physicists graduating in 1957, 15 specialized in low temperature physics, 26 in optics, 91 in nuclear physics, 135 in radio physics and so on. It was claimed that there was a free choice for the student when it came to specialization though the needs of the economy and of industry would be explained to him, but " if a man has made up his mind to study optics, nothing will change him ".

CONCLUSIONS

The system of physics teaching in the U.S.S.R. is impressive and there is plenty of evidence for the success of the system.

There are cynics who will suggest I was only shown what was best: I have no doubt that I did not see what was worst, but again and again when I visited a school they were unaware of the precise reason for my visit. The fact that they had to cancel the proposed conducted tour of the school as a whole to let me spend all my time in the physics department suggests that I was not being shown " special " lessons. The system was too good to necessitate that. Even if the standards claimed are not always achieved (and which of our western countries can claim that all our schools live up to our ideals as far as education is concerned), the system is most impressive. The place that physics has in the general educational system and the whole attitude to work in pupil and teacher alike are things of which we should take note.

The content of the syllabus certainly shows an awareness of modern physics. It is a somewhat solid syllabus and the textbooks that accompany it lack any of the imaginative development suggested by the O.E.E.C. report " A Modern Approach to School Physics "*: one is conscious of utilitarian objects rather than cultural ones.

What therefore have we to learn from it ?

I would suggest there is one very big lesson. In England our teaching is geared to the good teacher. Provided a school has an inspired teacher with sufficient time to prepare his work, good physics teaching will result. In the U.S.S.R. they accept that there will never be enough really good teachers (as is the case in most countries) and they have planned their system to enable the indifferent teacher to teach well. The development of aids to teaching, the thought that has been given to demonstration apparatus and to the experimental work to be done by the pupil, the attention to the right kind of films, all this has meant that teachers everywhere have been given a minimum standard to enable them to achieve a certain efficiency.

The O.E.E.C. report criticized the usual presentation of physics in schools on the grounds first that it was dull and made " no conscious attempt to build upon the natural advantage which the science teacher has in the common curiosity of children about the world in which they live and their present-day familiarity with outstanding examples of applied sciences " and secondly that it failed to give children a broad picture of what modern science is about. The Soviet system is an answer to this.

The Soviet teachers have been provided with a basic course complete in itself with all the necessary aids to present the subject and maintain the full interest of the pupils. The Americans have also found the need for this: the P.S.S.C. scheme meets their requirement of a one year course in physics. Other countries in Western Europe might profit by developing their own physics teaching on similar lines by giving thought to demonstration equipment and other aids in a way that is certainly not done in England at the present time.

* Published in the September 1960 *Bulletin* as " The Teaching of Physics in Schools ".

Notes and News

Summer vacation

Members are asked to note that the headquarters building at 47 Belgrave Square will close at 5 p.m. on Friday, August 4, and reopen at 9 a.m. on Tuesday, August 8.

The Simon Memorial Prize

Professor Sir Francis Simon was an international figure in the field of low temperature physics. The low temperature school at the Clarendon Laboratory was largely his creation. He was one of those instrumental in founding the Low Temperature Group of The Institute of Physics and The Physical Society and was its first Chairman. It was therefore natural that, after his death, the Low Temperature Group should have founded the Simon Memorial Prize which is financed from a fund to which many industrial organizations generously subscribed. The Memorial Prize is £250 which is awarded every two or three years to a scientist who has made major contributions in the field of low temperature physics.

The Simon Memorial Prizeman for the year 1961 is Dr. I. M. Lifschitz of the Academy of Sciences of the Ukranian S.S.R., Kharkov.

Dr. Lifschitz has made many penetrating contributions to the understanding of the structure of the Fermi-Surface in metals besides working on liquid helium. He has accepted this award and it is hoped that he will deliver a Memorial Lecture in September. If Dr. Lifschitz is able to come to deliver the lecture, full details will be announced later.

Rheological Techniques

The British Society of Rheology and the Non-Destructive Testing Group of The Institute of Physics and The Physical Society will hold a joint conference on Rheological Techniques in Llandudno from Wednesday, September 20, to Friday, September 22, 1961. A wide range of techniques will be discussed, and it is hoped that a number of pieces of apparatus will be demonstrated. It is intended that the atmosphere of the meeting, which will be open to persons who are not members shall be informal. Workers in fields not primarily concerned with physics or mechanics will be welcome.

Details of the programme can be obtained from Dr. Peter Lord, Royal College of Advanced Technology, Peel Park, Salford, 5, through whom bookings for accommodation can be made.

The Second International Conference on Stress Analysis

The Second International Conference on Stress Analysis organized by the Groupment pour l'avancement des Methods d'Analyse des Contraintes (GAMAC) will be held in Paris from April 10 – 14, 1962. It is not intended to include review papers in the Conference. Contributions will deal mainly with the results of experi-

RADIO SPECTROSCOPY OF SOLIDS

The Institute and Society jointly with the British Radio Spectroscopy Group is arranging a conference on " Radio Spectroscopy of Solids ", in the Department of Physics of the University College of North Wales, Bangor, on September 21-22, 1961.

The Institute and Society's Guthrie lecture will be presented during the Conference by Dr. D. Shoenberg, F.R.S., who will speak on :—

The de Haas-van Alphen effect and the electronic structure of metals

Residential accommodation will be available. Programs and application forms may be obtained from the Administration Assistant of the Institute and Society.

X-RAY ANALYSIS GROUP

AUTUMN CONFERENCE

on

IMPERFECTIONS IN CRYSTALS

November 17 and 18, 1961

at

The Institution of Mechanical Engineers, London

Session subjects will be as follows:

The nature of crystal imperfections and of associated diffraction effects.

Experimental methods for studying imperfections. Effects on physical properties.

Included in the invited speakers will be Dr. P. B. Hirsch, F.Inst.P., of the University of Cambridge, and Professor F. C. Frank, O.B.E., F.Inst.P., F.R.S., of the University of Bristol.

Enquiries regarding the program should be addressed to the Honorary Conference Secretary, Dr. G. S. Parry, A.Inst.P., Department of Chemical Engineering, Imperial College of Science and Technology, Prince Consort Road, London, S.W.7.

Registration is necessary. Further particulars and application forms may be obtained from the Administration Assistant of the Institute and Society in early September.

mental work, and there will be no publication of the complete texts by GAMAC. The Joint British Committee for Stress Analysis is arranging for the scrutiny of the British contributions on behalf of GAMAC. Abstracts and summaries must be submitted by September 30, 1961. Further information may be obtained from The Secretary, The Joint British Committee for Stress Analysis, The Institution of Mechanical Engineers, 1 Birdcage Walk, Westminster, S.W.1.

Third International Symposium on Rarefied Gas Dynamics

The Third International Symposium on Rarefied Gas Dynamics will be held at the University of Paris, June 26–29, 1962. The program will range from topics of immediate significance for upper atmosphere and space flight to basic scientific studies. Inquiries should be addressed to Laboratoire d'Aerothermique, 4c route des Gardes, Meudon (S & O), France.

National Conference on Engineering Inspection and Non-Destructive Examination

The Institution of Engineering Inspection and The Society of Non-Destructive Examination are joint organizers of a Conference on Some Aspects of Engineering Inspection and Non-Destructive Examination to be held in Oxford from September 5–8, 1961. Details may be obtained from The Oxford Conference Secretariat, The Institution of Engineering Inspection, 616 Grand Buildings, Trafalgar Square, London, W.C.2.

The Institute and Society is arranging

a Symposium on

"Some aspects of the physics of space research"

to be held at the

Royal Military College of Science, Shrivenham

from

20 - 22 September, 1961

Subjects to be discussed are:

The advantages to physicists of space research;
Cosmic rays, particle physics and meteorology
Physical techniques in space research
Rockets, orbits and trajectories

The symposium will be residential. Further details may be obtained from the Administration Assistant of the Institute and Society.

The Institute and Society,

on behalf of

The International Union of Pure and

Applied Physics and the

British National Committee for Physics

is arranging a

Conference on the

Physics of Semiconductors

at the

UNIVERSITY OF EXETER

on

JULY 16-20, 1962

It is expected that applications to attend will exceed the accommodation available and early application is therefore recommended. Details may be obtained from the Administration Assistant of the Institute and Society.

ELECTRONICS GROUP

Conference on

THE PHYSICS OF GAS DISCHARGE DEVICES

September 28 and 29, 1961

at

LEAMINGTON SPA

Topics to be considered will include:

Energy measurements in modulator thyratrons—comparison of the properties of hot cathode thyratrons containing the three isotopes of hydrogen—non-thermonuclear applications of high temperature discharges—problems of arc control—heavy current switching—very high current mercury pool switches—thermionic energy converters—gas-filled thermionic converters with ion injection—gas discharges as wave propagation devices—stabilizing tubes—corona stabilizers—surface emission of electrons by secondary processes in gas discharges.

A limited number of hotel rooms are available but bookings must be made as soon as possible. Information regarding hotel bookings and programs and application forms may be obtained from the Administration Assistant of the Institute and Society.

The Annual Dinner

The Annual Dinner of the Institute and Society was held at the Park Lane Hotel, London, on Tuesday, May 2, and was attended by 284 members and guests. They were received by the President and Lady Cockcroft. There were no formal speeches after dinner; the President briefly welcomed the guests and Sir Howard Florey replied. A number of exhibits had been arranged and members and guests appreciated the opportunity of seeing these and talking to friends.

Among the Institute's and Society's official guests, most of whom were accompanied by their ladies, were Sir Howard Florey (*President, Royal Society*), Dame Mary Smieton (*Permanent Secretary, Ministry of Education*), Sir William Slater (*President, Royal Institute of Chemistry*), Sir Gerard Thornton (*President, Institute of Biology*), Sir Herbert Manzoni (*President, Institution of Civil Engineers*), Sir Kenneth Hague (*President, Institution of Mechanical Engineers*), Sir Hamish MacLaren (*President, Institution of Electrical Engineers*), Professor H. O'Neill (*President, Institute of Metals*), Dr. W. A. Macfarlane (*President, Institute of Fuel*), Sir Gordon Sutherland (*Director, National Physical Laboratory*), Sir Christopher Hinton (*Chairman, Central Electricity Generating Board*), Sir Harry Melville (*Secretary, D.S.I.R.*), Dr. T. H. Osgood (*Scientific Attaché, American Embassy*), Dr. Scott E. Forbush (*Charles Chree Prizeman*), Sir Lawrence Bragg (*Honorary Fellow*) and Sir George Thomson (*Honorary Fellow*).

Sir Howard Florey, the President and Dame Mary Smieton.

Sir John and Lady Cockcroft.

(Above) Clockwise from extreme left: Mr. R. G. Elkington, Mr. J. A. Ratcliffe, Mrs. Whiddington, Professor B. H. Flowers, Mrs. Andrade, Professor E. N. da C. Andrade, Dr. M. R. Hopkins and Professor R. Whiddington.

(Left): Sir George Thomson being received.

Sir Christopher and Lady Hinton with the President and Lady Cockcroft.

Sir Herbert Manzoni, Lady Cockcroft, Sir Lawrence Bragg and Lady Manzoni.

(*Above*) *Clockwise from extreme left: Dr. C. Sykes, Professor P. M. S. Blackett, Mr. O. W. Humphreys, Lady Darwin, Dr. N. Blackett, Mrs. Sykes, Sir Charles Darwin and Mrs. Humphreys.*

Mr. J. R. Atkinson and Dr. J. M. A. Lenihan.

Dr. R. A. Smith at the reception.

Sir Andrew McCance (left) and Dr. W. H. Taylor.

Reviews of Books

MATHEMATICAL PUZZLES AND DIVERSIONS FROM *SCIENTIFIC AMERICAN*
By Martin Gardner

London: G. Bell and Sons Ltd. Pp. x+163. Price 17s. 6d.

The justification of applied science is the increased human satisfaction which logically organized creative activities can provide. Familiar branches of technology have thus arisen to satisfy the needs of economic man—food, shelter, transport, communications. But economic man is not the whole animal: there are contexts in which this is over-simplification.

The human need for enjoyment, fun, relaxation or diversion is equally real, and no less important. The scientific contribution here need not be restricted merely to improving communication facilities.

Few indeed have not at some time found enjoyment in some form of logical or mathematical puzzle, or in handwork involving some measurement and careful execution. This is true from the school pupil to the Nobel laureate, and applies equally to many whose working lives involve little mathematics or science.

This is a spark to be carefully fanned at a time when appreciation of the power of mathematics as a logical tool is necessary in an ever widening field of activities. The increasing circulation of books of mathematical recreations may well be a hopeful omen.

Some of the best work of this type in recent years has appeared in the "Mathematical Games" feature of *Scientific American*, since the end of 1956. This is notable for the amount of truly original material attractively presented; Mr. Gardner is an ingenious inventor himself, and can tap a wealth of other sources—many of considerable academic distinction. He can claim first publication of much which otherwise has travelled only through personal contacts. Many will already owe him thanks for enjoyment they might otherwise have missed.

This book collects his sixteen first articles, with about one-quarter as much again from afterthoughts and resulting correspondence. Topics range from card-trick and memory-display techniques through fallacies and pictorial topology to the construction, manipulation and strategy of kinematic devices and games for one or two persons.

Flexagons, "Hex" and polyominoes will especially divert the professional mathematician, while amateurs should find them equally enjoyable in a less sophisticated fashion. Two chapters are each a mixed collection of nine excellent shorter problems.

Many will buy copies to put on their own shelves beside Coxeter's revision of Rouse Ball; they may also win merit by presenting it to younger acquaintances. Enlightened schools will hasten to put it in their libraries; it could give a first and possibly decisive glimpse of the varied things mathematics can do, and what fun this all can be. We may note with satisfaction that material for other collections is still accumulating at a constant rate.

T. H. O'Beirne.

PHYSICS.—THE PIONEER SCIENCE. Volume I, Mechanics, Heat and Sound. Volume II, Light and Electricity.
By Lloyd W. Taylor

New York: Dover Publications, Inc. Pp. 847+xliv. Price $2.00 each volume.

At the present time there is a general climate of dissatisfaction with the teaching of physics; there are many who think that the methods so far used—which have of course produced them and all their generation of physicists—are dull and old-fashioned. Dr. Lenihan in a review in the March issue of the *Bulletin* described an all-embracing American attempt to reorient our methods; the present book—also American—describes what may be termed the opposite approach to reorientation.

Dr. Lenihan says that "the Physical Science Study Committee uses the historical approach cautiously and only where it is relevant . . .". This book* is, to a first approximation, completely historical. For example, magnetism is introduced in twenty pages of historical matter, illustrated by some early woodcuts and by photographs of the personalities involved. This is an extreme example, but it gives a fair idea of the contents of the book.

The historical approach takes precedence over rigorous presentation. For example, in the treatment of sound, much is made of architectural acoustics and elementary wave analysis, but no mention is made of the relation between frequency, length, density and tension for a stretched string. (Strangely enough, however, knowledge of this is assumed in one of the examples at the end of the chapter).

There can be no gainsaying the author's enthusiasm for physics, nor the way in which this enthusiasm is communicated to the reader. He was (for he died a few years ago) obviously a cultivated man, who spared no pains to study the background as well as the content of physics; the list of 291 items in the bibliography, dating from 1543, provides ample evidence of his interests. For the practising physicist, who is already familiar with the background of his subject, the book contains a great deal that will instruct and entertain him.

But is this the way to teach physics? Regretfully, I think not. The embryonic physicist will find the pace too slow and not rigorous enough; other embryonic scientists will probably (more's the pity) find the treatment boring; the non-scientist may well find that the treatment suits him, but it may nevertheless give him the wrong idea of physics—history with a different slant!

I therefore return to the suggestion that the people who will like this book are those who already have their basic physics behind them and who can afford to re-read it, so to speak, with their feet on the mantelpiece. Those who have not lost their sense of wonder at the simple phenomena of physics will be able to admire the ingenuity of the pioneers who, with immense sagacity, produced the physics now taught in schools. One hopes that they will try to pass on to their pupils *some* of the background they have learnt from this book.

This review tempts me to conclude with an opinion on the teaching of elementary physics. The problem, as I see it, is not (*pace* Dr. Lenihan and you, Mr. Editor) to see, from our elevated station, what we could have rejected from our elementary courses, but to put ourselves into the spirit of a youngster to whom neutrons and protons are adult ideas, and to whom a magnet and a compound pendulum are exciting pieces of apparatus—because he can use them himself. This book has much in common with these ideas, but it has too much in it and has not enough foundation to justify the superstructure.

H. Lipson.

* The work was originally published in one volume; it has been separated into two parts for this paper-backed edition, but the pages in Vol. II follow on from Vol. I.

MODERN DIELECTRIC MATERIALS

Edited by J. B. Birks

London: Heywood and Co. Ltd. Pp. 253. Price 42s.

The aim of this book is to provide an introduction to the wide range of dielectric and insulating materials that are used in modern electrical technology. It is intended for engineers, physicists and chemists who are interested in the manufacture, development or practical applications of dielectric materials. The book certainly achieves its aim and can be thoroughly recommended.

A particular feature is the comprehensive character of the book. The editor claims that it includes all of the solid and liquid dielectric materials which, by their combination of insulating properties with useful mechanical, thermal and chemical properties, have merited large-scale production and exploitation.

After an introductory chapter on dielectrics in general there follow chapters by specialist authors on paper, hydrocarbon insulating oils, chlorinated hydrocarbons, natural and synthetic rubbers, synthetic high polymers, silicones, ceramics, glass, mica and micanite, and fibres and textiles. The general pattern is to provide an account of the type of material under consideration and of the physical and chemical factors responsible for its particular properties. The composition and structure of individual materials and the appropriate fabrication techniques are described. Every chapter contains tables listing materials under their chemical or trade names and comparing their properties. For example, the chapter on high polymers contains 16 such tables and the inclusion of four pages on polypropylene indicates its completeness.

The chapter on ceramics differs somewhat from the others, the numerical data being chosen to illustrate the range of properties available rather than to describe particular materials. In general materials are designated only by composition, and not by trade names, in this chapter.

The index is comprehensive as regards the names of materials mentioned, but is less complete in other respects. For example, the section on piezoelectrics is listed only under that name and not under electromechanical transducers. Most chapters include a bibliography of books and review articles.

The most notable omission is the anodic oxides, such as those of aluminium and tantalum. Magnesium oxide and Mycalex might also have been included. However, for 253 pages, the coverage is remarkably complete, and the book successfully combines the qualities of a readable introductory account and a reference handbook.

B. Lewis.

THE EVOLUTION OF PHYSICS

By Albert Einstein and Leopold Infeld

London: Cambridge University Press. Pp. xvi + 302. Price 13s. 6d.

It is good to have this excellent—and inexpensive—re-issue of this little classic of exposition, which originally appeared in 1938. That it demonstrates the possibility of discussing such a theme without the introduction of a single mathematical formula is in itself a tribute to the authors' grasp of their subject matter. Indeed, this is the ideal book for the honours student in physics, except that, if he relied upon it alone, he would be most unlikely to pass his examinations. This brings us to the heart of the matter. The distinguished writers are concerned with principles, not with the experimental means by which they are verified or rejected. And their whole emphasis, as the title states, is upon the evolutionary character of man's thought in the realm of natural philosophy rather than upon the course of history, as events happened at such-and-such a time. But the layman must not infer from this that these pages have been composed to make things easy for him. On the contrary, he will find much that is difficult, and moreover, much that seems at first sight to be against common sense. Here is the next hurdle to be overcome. Sometimes we have been taught that science is just a rarified form of commonsense. This is a most dangerous doctrine, as the authors point out, and amounts to little more than an attempt to avoid the rigours of deep thought. By all means let us accumulate as many facts as possible, but the solution of the problem (what the facts mean) is not an exercise in common sense, but the application of the highest mental faculty possessed by the human species, the power of pure ratiocination. And this may lead (and often has led) to results at variance with ingrained habits of thought, and yet a crucial test has validated the predictions of reason.

This book does not explicitly say so, but it is hereabouts that both the conflict and unity between physics and philosophy are encountered. The latter discipline leaves room for a strong element of intuition: physics has on occasion been advanced by just this same faculty. Wherein then lies the trouble ? It arises, if and only if, this step is taken on a worldly-wise plane, and not in that of a universe of discourse which cares nothing for precedent, and still less for application. Intuition is probably essential for great discovery, but it needs detachment, utter and entire. Then mankind has reached a new stature, and a fresh chapter begins. So much for the spirit of this volume, which is all-important.

Now for the contents, only to be appreciated in the light of the above. We begin with the rise and fall of the mechanical view of nature. Everybody knows what that means, and there is no need to discuss it, except to say that it is faultlessly presented. Next comes field-theory and relativity. This drives us back well and truly

to basic positions. It is so much easier to think about particles than about the field in which they are immersed (and in which we ourselves are also immersed). And yet, if progress is to be made, we are obliged to make the field our study. The whole unhappy business of the ether turned on this: the conviction that there must be a field and yet that it must needs be mechanical, having, as a result, outrageous properties. And as we know, it had to go. All this, the authors explain. Lastly, there is the quantum theory. This means discontinuity in nature, not only in particles but in energy (a hark-back to the predominance of field-concepts). And thereafter comes probability in place of certainty. The last phase of all this has by no means been written, but little has happened since 1938 to disturb such deep waters as these. Only ripples have been our lot so far.

F. I. G. RAWLINS.

INTRODUCTION TO MECHANICS, MATTER AND WAVES

By Uno Ingard and William L. Kraushaar

Massachusetts and London: Addison-Wesley Publishing Company, Inc. Pp. xv+672. Price 53s.

Several interesting features distinguish this excellent textbook (which comes from the Physics Department of M.I.T.) from the usual run of books on mechanics. First, its experimental approach to the dynamical concept of force. Next, it takes to first-year university level the type of treatment that the Physical Science Study Committee's textbook uses for fairly mature school pupils. Also, wherever it is possible to discuss mechanical ideas relevant to heat, thermodynamics electrodynamics, crystal physics, and nuclear physics, the opportunity is taken; indeed, this is a fairly complete course in basic physics.

Looking back a generation or so, one is tempted (ungratefully) to wonder why mechanics has not always been presented to the young physicist in this kind of way. There seemed then to be a vast literature on Statics that had to be worked through. Think of S. L. Loney, who caught the young with *Elements of Statics*, followed up with *Elementary Statics*, progressed at the junior undergraduate level to *Statics*, and probably had further members of the series in reserve for those of riper years. Professors Ingard and Kraushaar are more concise; they devote exactly three pages to Statics. In the old days, too, physics students tended to regard mechanics as a "dry" subject almost unrelated to the serious business in hand, with the unfortunate result that many would try to tackle the higher flights without a thorough elementary grounding in mechanics. The student to-day, with relativity and the microscopic world before him, knows better; and books such as this provide him with the introduction and the encouragement that he needs.

And more than encouragement. Dynamics is difficult for the young; the idea of acceleration itself sinks in but slowly before sixteen, the notion that there is any other kind than uniform acceleration takes another two years, and only the best S-level candidate can handle the laws of motion with real confidence. (Mathematicians may dispute this picture; but I am not talking about learning the drill for solving the kind of dynamical problem that mathematicians set, which is not so hard). This is because it is not easy to study motion, even of the simplest kind, experimentally in a way that allows a clear analysis of the situation; and this has to be done if it is to be understood. The authors realize this, and a great deal of the earlier part of the book is devoted to the study of one-dimensional collisions between trolleys and two-dimensional collisions between frictionless pucks—the paths in the latter case being followed by high-speed flash photography, with many beautiful pictures which look very much like enlargements of cloud-chamber collision photographs. The reader is really helped to visualize what is happening. Thus it is made *no more difficult than Statics*.

With the foundations thus laid, the dynamics of rigid bodies, motion in Galilean and accelerated frames of reference, and the kinetic picture of matter follow easily; and the book ends with a clear presentation of wave motion.

The style is lucid, the illustrations good, and the problems and exercises have been compiled with imagination and test intelligent understanding rather than mere absorption of the bookwork. These themselves would make the book a useful acquisition for the teacher.

G. R. NOAKES.

MICHAEL FARADAY—A LIST OF HIS LECTURES AND PUBLISHED WRITINGS

By Alan E. Jeffreys

London: Chapman and Hall Ltd., published on behalf of The Royal Institution of Great Britain. Pp. xxviii+86. Price 42s.

It is difficult in a book title to give an adequate indication of the scope of a bibliographical work. Thus, though the title implies that all Faraday's "lectures and published writings" are included, two classes of material falling within these categories have been omitted. These are, firstly, personal and miscellaneous letters from Faraday which have been published collectively in book form, and secondly, "a small corpus of spiritualist literature" which Faraday "seems to have inspired". These categories are not, however, of the highest importance and by his manner of dealing with them in his Introduction the author has gone some way towards assisting the reader interested in tracing such publications. A third limitation is that the bibliography includes only material published in English in Britain. This restriction does not, however, apply to the list of biographical references included in the book.

In addition to material covered by the title there is much manuscript material which would find a place in a comprehensive bibliography. Apart from lecture notes at the Royal Institution such material is not included in the itemized bibliography, but again the Introduction describes briefly the nature and whereabouts of the many Faraday manuscripts which the author came across in the course of his studies.

The work contains a two-page list of selected biographical references followed by the main bibliography of nearly 500 primary items relating to first publication either as lectures or printed works, all arranged in a single chronological sequence. In addition, books appearing in revised or reprinted editions are listed under

the year of the first edition as well as under the year of publication. Similarly the listed lectures are inserted under the year of delivery as well as under the year of printed publication. The book ends with an 11-page index on a subject basis, though it is, in fact, an alphabetical index of " catchwords " in published titles.

This bibliography is an important addition to the writings on Faraday and we may hope that other authors will interest themselves in the territory still to be covered.

The typography and lay-out are good. Spot checks revealed very few spelling or other typographical errors, and the only one seen that would be likely to inconvenience the user was the spelling " Jarrold " for Jerrold on page xxv.

D. CHILTON.

AN INTRODUCTION TO THE LAPLACE TRANSFORMATION WITH ENGINEERING APPLICATIONS

By J. C. Jaeger

London: Methuen & Co. Ltd. Pp. viii + 156. Price 10s. 6d.

The first edition of this book appeared in 1949 and was based on a course of lectures delivered to engineers and physicists. It aimed to meet the growing demand for a knowledge of operational methods by those whose mathematical knowledge was limited to that of a Higher National or Degree course in engineering. No mathematics beyond ordinary calculus was used.

In producing the revised edition the author has in mind that many engineers are now forced to acquire some knowledge of the theory of functions of a complex variable because of its importance in modern circuit theory. He has, therefore, added a chapter dealing with some of the high-lights of complex variable function and its application in conjunction with the inversion theorem. Many will feel the book to be worth buying for this most readable introductory summary of a topic which is often shrouded in obscurity. An introduction to the Nyquist criterion for stability is included. No attempt has been made, however, to use the complex variable throughout. Many problems are solved by mechanical use of either the table of transforms or of expansion formulae. The book contains a large number of worked examples, based mostly on engineering applications, and many others for the reader to attempt. It is written in the direct and lucid style which we have come to associate with Professor Jaeger.

J. CRANK.

IMPERFECT PICTURE

By Edward F. Emley

Cambridge: W. Heffer and Sons Ltd. Pp. viii + 194. Price 15s.

This is a very personal book, and no one is going to treat it with the analytical criticism which would be expected if the deceased author of its essays had himself issued them as a book. A. C. Jessup, eminent technologist to the magnesium industry of France and England, was a striking answer to the usual indictment of our scientific narrowmindedness: poet, musician, mountaineer, and in these essays philosopher. Many to-day will value the intimate and unorthodox and intensely honest considerations that he brought to bear on the problems which stir scientists and all other folk concerned with human destiny, and which are here gathered and edited with care and affection by E. F. Emley. The widespreading meditations will probably be more lasting than the portions of the book which deal with theoretical nuclear physics and relativity.

MARTIN JOHNSON.

LINEAR CIRCUITS

By R. E. Scott

Massachusetts and London: Addison-Wesley Publishing Company Inc. Volume 1. Pp. xii + 510. Price 38s. Volume 2. Pp. xi + 928. Price 38s.

This comprehensive two volume work by the Professor of Electrical Engineering at North Eastern University is intended for electrical engineering students. Those reading physics would probably only in general be sufficiently interested or have sufficient time to read selected parts of it. The treatment throughout is exceptionally thorough and there are unusually comprehensive selections of problems at the ends of the chapters.

The first volume deals with Time-Domain Analysis comprising resistive circuit theory and transients in the time domain. There are 14 chapters in this volume, the first five of which deal with network theory, etc. leading to (chapter 5) the reduction of 2, 3 and 4 terminal networks. Then follow treatments of energy storage and the differential equations of electric circuits and a group of five chapters on time response theory. The latter deals mostly with fairly elementary cases and partly on time domain selections for arbitrary exciting functions. The final chapter deals with energy in circuits with storage elements.

The second volume is on steady state a.c. theory and transients in the frequency domain. There are five chapters in the former part of the book dealing with a.c. Equivalent circuits are treated in considerable detail, although not in any advanced fashion, and the a.c. part is completed with a study of power in a.c. circuits. Then follows a chapter on signal analysis comprising a detailed Fourier treatment, again with a very good selection of problems, covering in this case about 15 pages. The final three chapters are on network response to complex waves of excitation, Laplace transforms and power and energy networks excited by arbitrary functions.

J. D. CRAGGS.

PHYSIQUE DE BASE—POUR BIOLOGISTES—MEDECINS GEOLOGUES

By L. Lliboutry

Paris: Masson et Cie. Pp. xv + 368. Price NF 38.00.

A missionary preaching to newly converted savages does not, if he is wise, stress too much the theological subtleties which co-ordinate propositions readily accepted by the robust faith of his hearers. Those who hold that faith unsupported by sound doctrine risks relapsing into

superstition will nevertheless view his success with some reserve.

M. Lliboutry teaches physics to the natural scientists at Grenoble, where he fights on two fronts, against the natural resistance of natural historians to natural philosophy, and against the bad tradition—even more entrenched in France than this country—that physics is applied mathematics. His foreword, in which he analyses these difficulties, wins our respect and sympathy. He admits that students will not work readily, especially when overloaded, unless with an examination and a certificate in view. This book is specifically written for the preliminary physics courses for students of natural sciences and medicine. It covers a very wide range of information with a minimum of mathematical discussion.

This has the unfortunate consequence that many important results are quoted with " On démontre— " instead of a derivation. If these deficiencies were supplied by the lecturer—or, even better, by the student —one would have an admirable course of general physics, overlapping, as a course for natural scientists must do, into physical chemistry to a very pleasing extent. In fact, an honours physics student would gain a great deal from working through the book in this way.

Unfortunately, the first year student for whom the book is meant will have difficulty in filling in most of the missing argument. The examples at the ends of the chapters will confirm his grasp of what he has actually read, but his knowledge may remain at a " cookery book " level and his grasp of principles may be very shaky indeed. It may be proposed that no better can be done with this class of student, but in this country we seem to prefer, rightly as I believe, a deeper grasp of more elementary material, though we pay for this in our common failure to catch the interest of, say, the medical student who wants to see his physics in direct biological application. The dilemma can only be resolved by more and better teaching of science at earlier stages.

The teacher of physics at sixth form level and above will find much interesting and suggestive material in this book. Few of us will wish to recommend it to students.

G. Wyllie.

NEW SOVIET SURGICAL APPARATUS AND INSTRUMENTS AND THEIR APPLICATION

Edited by M. G. Anan'yev. Translated from the Russian by J. B. Elliot.

Oxford : Pergamon Press Ltd. Pp. x+ 222. Price 80s.

This book contains 34 papers by Russian surgeons and engineers. Most of them deal with the design of surgical instruments and their application in operations on dogs or human patients. The two main topics are the development of heart-lung machines and the use of ingenious stapling devices for repairing damaged blood vessels and joining various tissues during surgical procedures. Other contributions discuss electrically-induced anaesthesia, cardiac defibrillators and general problems of instrument design. A recurring theme is the inadequacy of the surgical instruments available in Russia.

British readers will find the book of little value. Instruments are illustrated by line drawings without any indication of dimensions or materials. Electronic apparatus is described in the most general terms with no details of circuits or components.

The book is reproduced from typescript by photolithography. The publisher explains in a notice to reviewers and readers that printing by the normal method would have delayed publication by many months ; this excuse is hard to accept, since the original Russian edition was published as long ago as 1957.

J. M. A. Lenihan.

THE INTERNATIONAL DICTIONARY OF PHYSICS AND ELECTRONICS

Princeton and London : D. Van Nostrand Co. Ltd. Pp. 1355. Price 205s.

Despite the cost of this work, its generally careful compilation (see, however, below) and its excellent preparation, binding, etc., there is little that a reviewer can usefully write about it. Libraries will purchase it, because scientific dictionaries have arrived and because this is a useful example of such books. The entries tend to be small and definitive rather than encyclopaedic and descriptive.

The entries vary from the peremptory

" starting voltage: see voltage, breakdown. The use of the term starting voltages is deprecated."

through the ridiculous

" voltage, heater: the voltage between the terminals of a heater ".

to the acceptable, e.g., containment time, thermal units, etc., and very many others.

J. D. Craggs.

FUNDAMENTAL PHYSICS

By Jay Orear

New York and London : John Wiley & Sons Ltd. Pp. xiv+ 381. Price 54s.

This textbook was written as a one-year course for American College students who have had little previous training in mathematics and science. As a course for non-scientists it presents intriguing possibilities. It attempts to survey the whole of that part of Modern Physics which is considered fundamental, avoiding applied physics, and has quite obviously drawn much from the inspiration of the American Physical Science Study Committee. It is, however, open to considerable debate whether a student with no previous knowledge of physics can absorb in one year in anything more than a most superficial way a course which begins with elementary concepts of kinematics and concludes with the special theory of relativity, Einstein's mass-energy relation, energy levels in metals, the ideas and even a little of the mathematics of quantum mechanics, and a consideration of fundamental particles, antimatter and parity. The attempt is made; the text is well printed, clearly written and set out in a surprisingly extravagant format. But how much does a " quantised angular momentum vector " really convey to a non-scientist ? The text would require elaboration in careful lectures and its cost probably precludes its use as a classroom

textbook in English schools, on the other hand the course has apparently been successfully used in Cornell University. The book would be of considerable use to someone running a P.S.S.C. course as it contains much useful material to supplement it.

J. L. Lewis.

A TEXTBOOK ON LIGHT

By L. Mackinnon

London: Longmans, Green & Co., Ltd. Pp. xi + 344. Price 17s. 6d.

This is a new book presenting the subject to Advanced and Open Scholarship levels, with a little post-scholarship work thrown in. There are one or two quite good books already on the market covering this ground. What, then, does one look for in a new book? New material? There is not a great deal of scope here, but the author has taken every opportunity to see that the text is fully up-to-date. A new way of organizing the material? Again, of necessity, the book follows a mainly traditional pattern, and it does this with considerable success. There are good collections of questions, well arranged, and a fair quota of worked examples. A new style of treatment? Hardly " new " but one should mention here that, in the optics of lenses and mirrors, the emphasis is on wave-surfaces rather than on rays. Also worthy of note is the use made of the amplitude-phase diagram in interference and diffraction. A new sign convention? No ! ! but readers of this review will like to know that the author uses the RP convention in the form which treats all radii as positive and allots signs to refractive indices. A new production style? The production and diagrams are first class (except Fig. 8.3) but quite conventional, with a rather limited number of half-tones.

Is this book, then, to be labelled " just another A/S text on optics " ? Certainly not: there is much that stimulates thinking about the subject, but which is difficult to summarize usefully in a review. To provide such stimulus is one of the stated aims of the author. We are sure that he will elicit the desired response from an able student, but it is a moot point whether he will do so from the average G.C.E. candidate. This is a scholarly text written for scholars, but the less-than-first-class student at school may find it rather difficult.

R. Stone.

COUPLED MODE AND PARAMETRIC ELECTRONICS

By William H. Louisell

London and New York: John Wiley and Sons Ltd. Pp. xv + 268. Price 91s.

This is a very good book, carefully written and extremely well presented. The theory of coupled modes is introduced as an analytical tool at an elementary level in relation to simple harmonic oscillators. It is then applied to a variety of electronic problems involving electron beams, travelling waves and parametric systems which illustrate its power and usefulness in tackling new problems. The scope is best indicated by its chapter headings: (i) Theory of coupled modes; (ii) Some normal modes on electron beams; (iii) Space-charge waves coupled to slow wave circuits; (iv) Parametric coupling principle for lumped circuits; (v) Parametric coupling principle for distributed circuits; (vi) Semiconductor diode parametric amplifiers; (vii) Parametric amplification of fast space-charge waves; (viii) Fast cyclotron mode parametric amplifier; (ix) Ferrite parametric amplifiers. The subject matter is not confined entirely to those topics which can be treated by coupled mode techniques. Practical amplifiers are also illustrated and discussed with regard to gain and noise. There is a good bibliography at the end of each chapter, which is, perhaps, excessive for chapter iv, running to 206 references occupying more than 9 pages. The mathematics is nowhere difficult in the text; a few of the more advanced topics are treated in 12 appendices (34 pages). The book should be intelligible to final year physics and engineering students and deserves to be widely read.

F. J. Hyde.

EDITORIAL PRACTICE IN LIBRARIES

Edited by B. C. Brookes

London: Aslib. Pp. x + 204. Price 21s. to members of Aslib. 27s. 6d. to others.

Do not be misled by the title of this book, *Editorial Practice in Libraries*, into thinking that it has limited appeal and is perhaps not of interest except to editors or to librarians. One of its most valuable chapters " Editing a manuscript " describes what must be looked for in a scientific or other manuscript when submitted for publication. It therefore can be of very great value to the many readers of this *Bulletin* who are from time to time asked to scrutinize and " referee " a manuscript for publication by the Institute and Society.

The title given on the spine of the book *Editorial Practice* is perhaps a truer one, for the book describes the various processes involved in the passage of a manuscript from submission to final publication and points out the considerations which the editor must have in mind in his work. It is often difficult to decide for what readers such books as this are intended. There is no such difficulty with the present excellent little book—it can be read with interest and profit by anyone concerned with the publication of manuscripts, their own or those of others.

The book is presented in nine chapters, each prepared by an expert in the subject: The part time editorial department, by E. M. Simons; Printing: traditional processes, by T. Chapman, illustration processes, by M. Hepher; Special processes for short runs, by F. H. Smith; Buying print, by D. A. Ward; Layout and design by E. Hoch; Editing a manuscript, by B. C. Brookes; Preparation of illustrations, by C. Baker; Publishing, by P. Unwin; Publishing a specialized journal, by R. B. Roberts.

Each chapter contains a factual and explicit account of its subject, not too technical for a layman yet sufficiently detailed for the editor to use as a working guide, either for himself or for his assistants, or in his contacts with his printers, his blockmakers and his publishers.

The first chapter heading is " The *part time* editorial department " because the book is largely intended for the " amateur " editor, the man who has not been professionally trained and who may combine editorial work with other duties. In the course of his experience he collects

items of knowledge on associated subjects such as block-making, etc., he forms his own traditions in editing and in contacts with authors, he trains his sub-editors in their contribution to the work. Here the things he will have learned—and often many more—are set down in logical sequence.

At the present time, when the photographic and lithographic methods of printing are being developed so rapidly, the chapter on special processes for short runs will be extremely valuable to many people, for it describes these processes and the advantages and disadvantages of their use for various types of work.

The chapter on editing a manuscript should be studied closely by authors and by referees of scientific papers, for it sets out carefully and wisely the many points which must be considered in submitting a manuscript for publication.

This is in every way an excellent book—not least for the advice it gives to editors on the choice of a vocabulary—but why, one wonders, does the editor allow the word " insolubilizing " to creep in?

A. C. Stickland.

LABORATORY PHYSICS

By J. H. Avery and A. W. K. Ingram

London: William Heinemann. Pp. 513. Price 25s.

The third edition of this valuable book includes a number of new experiments, a chapter on transistors, and some new questions and exercises. The range of the ballistic galvanometer's repertoire has been extended, and valve data have been brought up to date.

The earlier editions were welcomed with a justified enthusiasm. This is not just a selection of experiments—it is a storehouse of experience. On nearly every page there is the note of warning that forestalls the obvious error—and so many of the things that appear obvious to boys are errors, besides which they seem to like their slips well shod. Don't use resistance wire for your bridge connections, don't assume the e.m.f. of a lead accumulator to be 2·000 volts, clean your lens surfaces . . . in fact, do things as a physicist who wants good physics, rather than as a child who wants the quickest " answer ".

Some stock experiments are often traditionally done the wrong way, or the hard way; and this book has some thoughtful improvements to suggest. The conductivity of rubber (as a tube) without condensation blockage, and Newton's rings used to find radius of curvature better than Boys' method instead of to measure wavelength worse than the diffraction grating, for example. The range of really instructive exercises provided far outruns the limits of likely examination problems of which more than a hundred are listed in their proper place—at the end.

G. R. Noakes.

PRINCIPLES OF STELLAR DYNAMICS

By S. Chandrasekhar

New York: Dover Publications, Inc. Pp. x+313. Price $2.00

Among the classics of physics and astronomy now reappearing in the Dover edition, it is especially pleasing to welcome this book, which nearly twenty years ago developed the application of generalized dynamics to the largest assemblage of " molecules " known, the hundred thousand stars of a cluster and the hundred thousand million of a galaxy. Worked out rigorously from first principles, beginning from Liouville's theorem and Hamiltonian equations, topics treated in detail include here the possible disintegration of star clusters, the sources of spiral structure in galaxies, and the time of relaxation of an initially disturbed assemblage. Astronomers have for many years looked to this gentle, modest, and widely beloved Indian scholar as the final arbiter of wide-reaching enterprises in cosmic dynamics; in his position as chief mathematician to the Yerkes Observatory of Chicago he has exercised a unique influence. But no one finds it easy to read the austere unfolding of his thought; it is a salutary lesson for physicists to be in the presence of his skill and his conscience on questions of the rigour of proof.

Martin Johnson.

SCIENCE AND EDUCATION — A POLICY STATEMENT :

Issued by The Science Masters' Association and the Association of Women Science Teachers (1961)

London: John Murray Ltd. Price 1s.

SCIENCE AND EDUCATION — PHYSICS FOR GRAMMAR SCHOOLS :

Issued by The Science Masters' Association and the Association of Women Science Teachers (1961)

London : John Murray Ltd. Price 2s.

Because the people in this densely populated island must live on their wits, education is the basic industry of this country. The present token strikes of teachers may be taken to indicate that at least some features of our educational ferment are becoming a tumult. The place of science in education has been a source of enlightened heat for over a century, an honourable agitation though scarcely an outstandingly successful one. There is a real danger that in our present crises, we continue to tinker instead of redesigning.

The welcome view of two authoritative committees of the S.M.A. and the A.W.S.T. on Policy and on Physics for Grammar Schools are clearly set out in these two pamphlets. I wonder why no one teaching in either Scotland or in Wales was a member of either of these committees ? The broad conclusions in the policy statement are that a study of science over seven years should be divided into three successive stages, Introductory, Intermediate and Advanced. " *All* pupils should follow a balanced course of science subjects up to the end of their fifth form year. . . . There should in fact be no division into science specialists and arts specialists until beyond this level, so that specialization in arts or sciences, or even a combination of the two, may be available to all pupils of the necessary ability when they enter the sixth form. . . . Science should be studied by *all* pupils in the sixth form ". Such opinions will surely find wide support. As always it is the practice which is the problem and my criticism of the proposed timetables set out in an appendix, is of the time devoted to history. Children are exposed to a fragmented education. The

focal elements in a coherent education are, in my opinion, Science—the study of the natural world and History—the study of the human world.

Physics for Grammar Schools is largely devoted to a draft syllabus which is divided into two parts. "Part I is intended to cover the first five (or in exceptional cases four) years of a grammar school course, during which the subject is taken by all pupils equally. This stage can be divided into two phases, the introductory (two years) and the intermediate phase (three years) of the whole course. . . . The advanced stage is dealt with in Part II. . . ." Writing a syllabus is a thankless task: most of the inevitable brisk criticism is very familiar to the drafters. The important thing is that this syllabus has been drafted as a systematic whole: perhaps the most significant statement is of principle. "We must develop a new system of school physics teaching. We cannot do this by teaching only the physics of generations long past, though that has its place. Present syllabuses are out of date". Every reader will have his own "alarms". I am sure no single member of the committee felt that all his pet topics had been included. My own criticism is that the committee have not been sufficiently radical, particularly in the Introductory Part I Syllabus which is too traditional. It takes time to persuade children of the need to be systematic. Indeed most adults don't recognize a system when they see it and small boys are marvellous wreckers of entropy. They are fascinated by an ordered system such as a bicycle and begin by disordering it. If you start with everyday experience and show the importance of organized system in an existing interest, the purpose of study—forces, couples, work, energy—becomes clear. Otherwise it remains imposed aimless memory work for all save those who are intellectually gifted.

G. K. T. Conn.

News of Members

FELLOWS OF THE INSTITUTE OF PHYSICS

J. Bell is now Managing Director of The M-O Valve Company Ltd., London.

Sir John Cockcroft has been elected Chancellor of the Australian National University, Canberra.

R. J. Clayton is the Head of the Telecommunications and Engineering Research Laboratories of "The Hirst Research Centre", Wembley, formerly known as the G.E.C. Research Laboratories.

V. J. Francis is Head of the Central Research Laboratories of "The Hirst Research Centre".

F. Llewellyn Jones has been appointed by the Ministry of Education to be Chairman of the Central Advisory Committee for Education (Wales), which is to consider the place of mathematics and science in a balanced education in Wales.

E. B. Moss is now Senior Staff Engineer with Douglas Aircraft Company, Inc., Santa Monica, California.

J. Taylor (Honorary Treasurer), a Director of Imperial Chemical Industries Ltd., has also been appointed to the Board of Pyrotenax Ltd.

L. A. Thomas has been appointed Chief Physicist at the Hirst Research Centre.

ASSOCIATES OF THE INSTITUTE OF PHYSICS

N. Adams has joined the Radiological Protection Division of the Health and Safety Branch of the U.K. Atomic Energy Authority at Harwell.

S. J. Carlile has been appointed Head of the Department of Physics at the Huddersfield College of Technology.

M. Cohen has taken an appointment with the Department of Research and Isotopes of the International Atomic Energy Agency, Vienna.

M. Gunston is a Mathematician in the Mathematics and Systems Analysis Group at the Marconi Research Laboratories, Great Baddow, Essex.

J. Hart has been appointed Professor of Physics and Chairman of the Department at Carleton University, Ottawa, Canada.

N. J. Hidden is a Physicist in the Research Department of British Plaster Board (Holdings) Ltd., Loughborough.

G. D. Lill is a Mineral Processing Engineer with Baker-Perkins Ltd., Letchworth, Hertfordshire.

E. Linacre is a Senior Research Officer at the Irrigation Research Station of C.S.I.R.O., Griffith, New South Wales, Australia.

D. M. J. P. Manley has been appointed a Lecturer in Physics at Farnborough Technical College, Hampshire, as from September, 1961.

C. S. Metcalfe is a Programmer with I.B.M. British Laboratories, Winchester.

J. R. Mills is now a Deputy Chief Scientific Officer in the Ministry of Aviation and Head of the Radio Department of the Royal Aircraft Establishment, Farnborough.

D. W. Stops has been appointed Reader in the Applied Physics Department of Northampton College of Advanced Technology, London.

J. D. Swift is now a Senior Lecturer in Physics at the Northern Polytechnic, London.

S. E. Warren has joined the staff of the Bradford Institute of Technology, as a Lecturer in Physics.

R. E. Weston, who is with Shell is now stationed in Venezuela.

P. M. Wolfenden has joined Courtaulds Ltd., Coventry, as a Development Engineer.

GRADUATES OF THE INSTITUTE OF PHYSICS

V. W. Adams has been appointed a Scientific Officer at the Royal Aircraft Establishment, Farnborough.

J. H. Bryce is now with the British Ceramic Research Association, Stoke on Trent, as a Senior Scientific Officer.

G. J. Cooper is a Computing Assistant in the Electronic Computing Laboratory at the University of Leeds.

I. R. Hardwick is now employed as an Engineer with the I.B.M. British Laboratories, Hursley.

I. G. Hood has joined the staff of the Technical College, Coatbridge, as an Assistant Lecturer.

J. W. Hood is a Technical Development Officer with Forestar, Land, Timber and Railways, Company Ltd., London.

R. A. S. Kay has joined the staff of A.E.I. (Woolwich) Ltd.

R. Lawrence is Assistant Professor of Physics at the University College of Addis Ababa, Ethiopia.

M. Malone is a Metal Physicist with the Battelle Institute, Geneva.

J. A. Robson is an Engineer with the U.K. Atomic Energy Authority at Windscale.

J. O. Rowan has joined Barr and Stroud Ltd. as a Physicist.

J. C. V. Rumsey has been appointed a Research Assistant in the Houldsworth School of Applied Science of the University of Leeds.

K. Wilkins is a Research Officer with the Central Electricity Generating Board at Berkeley Nuclear Laboratories.

A. W. Williams has been appointed an Assistant Lecturer in the College of Advanced Technology, Birmingham.

FELLOWS OF THE PHYSICAL SOCIETY

Sir William Penney has been appointed Deputy Chairman of the U.K. Atomic Energy Authority.

Manuscripts accepted for publication in the Institute and Society's periodicals

British Journal of Applied Physics

INVITED ARTICLE

Discourse on hydrodynamic research. By F. S. Burt.
A brief survey is given of some hydrodynamic research problems of particular interest to naval and marine applications. A description is given of model ship towing tanks and their use in studying resistance and propulsion problems of ships. The use of special sea-keeping and manoeuvring basins from model ship studies of sea-keeping and manoeuvring characteristics is mentioned. Another topic is the study of ship propulsion research and a description is given of cavitation tunnels and their use in this connection. Some detail is given of the particular sphere of underwater hydrodynamic research and the special facilities and instrumentation which have been developed at the Admiralty Research Laboratory for research into this specialized field including the use of slotted wall working sections in water tunnels and the large rotating beam channel.
The unusual hydrodynamic research problems associated with the entry of missiles from the air into the water are briefly surveyed as are those of two-phase flows in gas liquid mixtures.
The discourse concludes with a brief mention of possible high performance vessels of the future including hydrofoil craft, hovercraft and underwater cargo vessels.

INVITED ARTICLE

Thermionic generation of electricity. By M. A. Cayless.
A thermionic generator of electricity is essentially a diode valve in which electrons emitted from a hot cathode flow to a cooler anode, producing an electric current. From being scientific curiosities, such devices have become the subject of intense research activity in the last three years, and it is now clear that they have considerable possibilities as useful generators in a number of fields.
This article reviews this recent work and makes an assessment of the present position and future trends. Although engineering design and applications are considered, the emphasis is on the physical processes associated with these devices, and the progress which has been made into understanding them.

INVITED ARTICLE

The electricity of precipitation. By J. A. Chalmers.
Results of measurements on precipitation electricity are described and the problems of explaining them are discussed.

INVITED ARTICLE

Lead zirconate–titanate piezoelectric ceramics. By A. E. Crawford.
The disadvantages of ceramics based on barium titanate has limited many of the possible applications of this type of piezoelectric material. The Curie point is low and it is inefficient in electromechanical conversion. The discovery of the piezoelectric properties of the solid solution ceramics based on lead zirconate and lead titanate has stimulated increasing interest in transducer design. The paper describes the properties and characteristics of this new range of materials in terms of their ferroelectric and piezoelectric effects.

Optical absorption of some oxides in the Schumann ultra-violet region. By W. P. Doyle and F. J. F. Clarke.
The optical absorption of thin films of stannous oxide, stannic oxide, lead monoxide, the trioxides of arsenic, antimony and bismuth, beryllium oxide, zirconium dioxide and tantalum pentoxide has been measured in the energy range 4 to 10·5 ev.

Spectroturbidimetry of emulsions. By J. D. S. Goulden.
A theoretical treatment of the turbidity of monodisperse emulsion is discussed and its application to polydisperse systems indicated. Modifications required to commercial spectrophotometers for carrying out spectroturbidimetric studies are described. The determination of both mean globule size and concentration of the suspended phase in homogenized emulsions is illustrated.

Epitaxy and twinning in foils of some noble metals condensed upon lithium fluoride and mica. By M. J. Hall and M. W. Thompson.
Foils up to $2{\cdot}5 \times 10^{-5}$ cm in thickness, of Cu, Ag, Pd and Au have been evaporated on to LiF and mica crystals; epitaxial growth was observed

within fixed temperature ranges for each substrate-metal combination. X-ray diffraction of the foils produced sharp patterns of spots which indicated a principal orientation of crystallites in direct alignment with the substrate crystal, together with twins whose presence was confirmed by metallography. The observations are discussed in terms of a nucleation and growth model.

A light transmission technique for following continuous changes in optical retardation in polymer films. By J. H. Magill.
The light intensities (crossed and parallel polars) transmitted by a spherulitic polymer film of uniform thickness, have been measured using a photomultiplier-recorder system. These intensity measurements have been correlated with the optical retardations (Berek compensator) measured over the same temperature interval. The linear relationship obtained establishes the validity of the technique for following changes in optical retardation. Typical results are given for polyhexamethylene adipamide (66 nylon) and isotactic polypropylene polymer films.

The influence of alloy structure on the transfer of matter. By W. Merl.
The influence of conductivity on the transfer of matter at break (6 v, 4·3 A, 0·06 + 20 μH) was investigated for precipitation-hardened gold alloys and a palladium alloy with super-structure. For the gold alloys the degree of transfer depends strongly on conductivity in the regions of residual transfer and of normal arc, but is hardly effected in the region of the short arc.

Contact ferroelectric effect applied to plastic flow. By B. S. Satyanarayana.
Investigations made on the ferroelectric effect of manganese dioxide show that a phenomenon dependent on the efficiency of contact of the oxide surface with the electrodes exists. The apparent changes in the ferroelectric hysteresis loops with pressure on the electrodes are traced experimentally. The apparent contact variation of the ferroelectric effect in manganese dioxide is applied to a comparison of the plastic flows in indentations in metals, the indentations being made by the Vickers hardness diamond pyramid.

CONFERENCE REPORT

Summarized proceedings of a conference on x-ray analysis, Glasgow, April 1961. By J. C. Speakman.
The Spring Conference of the X-ray Analysis Group of The Institute of Physics and The Physical Society was held in the Chemistry Department of Glasgow University, on April 6 and 7, 1961. Dr. C. W. Bunn, Chairman of the Group, presided at the first and third sessions, whilst Prof. J. M. Robertson, F.R.S., was in the chair during the second session. The Evening Discourse on April 6 was given by Prof. R. V. Jones (Aberdeen University), who discussed some aspects of the direction of the national scientific effort in connection with the war of 1939–45 under the title, 'Philosophers and Kings'.

Counting statistics in x-ray spectroscopy. By R. C. Stanley.
An investigation has been made to see whether the secondary x-ray photons arrive in a random manner in a commercially available x-ray spectrometer, and if so, how the available counting time may be best used. A sufficiently large number of observations has been taken to allow a full statistical analysis to be made and compared with theoretical predictions. In addition, an experimental investigation has been made into the timing accuracy and its effect on the final count rate.
It was found that for very high counting rates, above 10,000 counts/s, or long counting times, above about 2 minutes, small instrumental errors tend to occur, but for count rates generally obtained in practice, the x-ray photons are emitted in a random manner and a Poisson distribution is obtained. In practice one could expect a single observation to be within 0·6% of the true value for a 256,000 count or 1·3% for a 64,000 count.
The necessary statistics for measurements of a given accuracy are set out in a form readily usable by the x-ray spectroscopist, together with formulae and procedure for obtaining the greatest net accuracy when only a limited time is available.

The capstan equation for strings with rigidity. By I. M. Stuart.
The effect of string rigidity on the capstan equation is considered. Two cases which cover the most likely situations are distinguished—contact of the string with the peg at a point, and contact over an arc. The analysis of these situations is facilitated by an approximation derived for the curvature for the leads of string on either side of the peg. If the friction is governed by Amontons' Law the correction of the capstan equation for string rigidity will usually be small, but in the case of arc contact and load-dependent coefficient of friction, the correction could be important.

Dynamic compression measurements of cushioning materials utilizing an analogue computer. By B. H. Venning and J. Guttridge.
Theoretical analysis of the design of packaged systems is readily carried out on an electronic analogue computer, but to introduce a realistic stiffness term it is necessary to know the dynamic performance under conditions similar to that of an actual impact. A system has been devised using an electro-dynamic force generator with force and displacement transducers to incorporate a sample of cushioning material into the analogue system, thus solving the cushioning problem under dynamic conditions. At the same time, waveforms of force–time and force–displacement are produced, showing the nature of the non-linear stiffness and the extent of energy dissipation.

Journal of Scientific Instruments

Digitiser to tape punch coupling unit. By L. Molyneux, E. E. Schneider and G. R. Sharp
The unit briefly stores the output (twelve binary digits) from an optical or mechanical digitizer and produces signals which will cause a high speed five track tape punch to punch the stored information in four rows of holes. Three rows contain the twelve binary digits from the digitizer while the fourth contains a marker hole and information set on four key switches. Except for the seven values necessary to drive the tape punch and digitiser light source the unit uses transistors as its active circuit elements.

Rotational vibroscope for the comparison of the torsional properties of thin fibres. By P. Nordon.
An apparatus is described for the measurement of the dynamic torsional properties of textile fibres in the frequency range of 1 to 100 c/s using forced oscillations. The apparatus is particularly suitable for following the kinetics of the change in torsional properties caused by changes in temperature and/or humidity of the air surrounding the test specimen.

Device designed to maintain a constant gas pressure in kinetic systems. By E. R. S. Winter.
A vacuum-tight stainless-steel piston pump containing mercury is described, which can be attached to a glass high vacuum line. The movement of the piston is controlled to raise or lower the level of mercury in a glass burette so as to keep the pressure in the system constant. The movement of the piston is recorded upon a chart driven by a synchronous motor to give a record of the volume change with time in the gas phase at constant pressure: three chart speeds are provided. Pressure control is by matched Pirani gauges in a Wheatstone Bridge network at low pressures, or by a mercury manometer with sealed-in metal contacts at higher pressures: associated circuits are described.

Proceedings of The Physical Society

Magnetostriction in antiferromagnetic nickel oxide. By L. Alberty and E. W. Lee.
Measurements of magnetostriction on a single crystal of antiferromagnetic nickel oxide were made in fields up to 21 kilo-oersteds. The order of magnitude of the magnetostriction is the same as that for ferromagnetic materials, viz. $\sim -20 \times 10^{-6}$, and a square law relation, with field, is obeyed up to several thousand oersteds before a gradual saturation tends to set in. The dependence of strain on field and measuring directions is described with respect to axes that constitute cylindrical symmetry.

Some physical properties of the γ and δ phases in the U–Zr system. By R. D. Barnard.
Electrical resistivity and magnetic susceptibility measurements are reported for U–70 and 74 at % Zr in both the γ and δ phases. Negative temperature coefficients of resistivity were found in the metastable γ phase of U–70 at % Zr, and also in the δ phase of both alloys between 90° and 870°K. The Pauli weak spin paramagnetism, exhibited by both specimens, always increased with temperature.
The bearings of the results on the conflicting opinions held on the crystallography of the δ phase, and on the explanation of the anomalous resistivity behaviour, are discussed.

Spectroscopic measurements of plasma containment in ZETA. By W. M. Burton and R. Wilson.
Observations are made of the time variation of the intensities of spectral lines emitted by small quantities of impurity ions in a deuterium discharge in ZETA. A vacuum ultra-violet monochromator which covers the wavelength range 500–2000Å is used. The observations are interpreted in terms of temporal ionization distributions determined for a partially contained plasma model. The observations are consistent with the model and it is shown that plasma containment in ZETA is violated by two processes—an escape of plasma to the wall represented by a loss rate coefficient $\lambda(\sec^{-1})$, and an injection of atoms in a neutral or low state of ionization represented by an injection coefficient $\Lambda\,(\sec^{-1})$. The value of λ is effectively independent of the stabilizing magnetic field strength (B_z), whereas the injection coefficient varies considerably with this parameter. Both λ and Λ are closely correlated with ϵ, the energy input per unit mass of gas, and over the range of conditions investigated they show a linear increase with ϵ. The ion containment time $1/\lambda$ is about 100 microseconds at $\epsilon = 3$ kev/m_D and at this condition most of the energy input is carried to the walls by the escaping plasma. The net effect of the processes of loss and injection controls the variation of plasma line density, and in general this shows a decrease with time or 'pumpout'. This is measured and related to other discharge phenomena.

The transfer and exchange transfer of nucleons between ^{16}O and ^{27}Al. By R. F. Coleman and J. L. Perkin.

Cross sections for the following reactions with 36 mev ^{16}O ions have been measured:

Neutron transfer	$^{27}Al(^{16}O, ^{15}O)^{28}Al \leqslant 7\ \mu bn$
Proton transfer	$^{27}Al(^{16}O, ^{17}F)^{26}Mg\ 210 \pm 50\ \mu bn$
Neutron–proton exchange transfer	$^{27}Al(^{16}O, ^{18}F)^{25}Mg\ 0{\cdot}7 \pm 0{\cdot}4\ \mu bn$.

The mechanism of the exchange transfer reactions is discussed in terms of the single transfer reactions. There is some evidence to suggest that an exchange reaction is not composed of two single transfer reactions.

The electric breakdown of sodium chloride. By R. Cooper and W. A. Smith.

The electric breakdown of sodium chloride has been investigated using flat-topped impulses. Statistical time lags exist and the average time lag depends on the nature of the cathode, and on the magnitude of the voltage increment. Evidence is presented of a small rate of decrease of the electric strength with increase in specimen thickness. The observed characteristics of breakdown are similar to those predicted by the single avalanche theory proposed by Seitz and according to which breakdown ensues the passage of an electron avalanche in excess of a certain critical size.

Observations on lattice rotations in tabular silver-bromide grains. By G. C. Farnell, R. B. Flint and E. Pitts.

In pure silver bromide emulsions containing tabular grains, some are found in which one part appears to have been rotated with respect to the other about an axis perpendicular to the large (111) faces. To ascertain whether such grains were genuine, possible angles of rotation and their frequency relative to one another were deduced on a simple theoretical basis. Similarity in calculated and observed angles and in the calculated and observed relative frequencies of occurrence, as well as the simple fact that the angles fall into well-defined groups, show without doubt that such grains are not artefacts but special forms of epitary. It is shown that the distribution of photolytic silver is profoundly different in such grains from that observed in normal grains.

The correction of signals distorted by linear apparatus. By C. P. Flynn.

In a previous paper by Flynn and Seymour published in 1960, a technique was developed whereby a type of distortion produced by linear apparatus could be corrected rapidly and efficiently to obtain a 'true' output signal. The distortion considered was not the most general linear distortion, and several cases of practical importance were therefore excluded.

In this paper, the general linear distortion is examined and equations developed which permit the rapid correction of distorted output signals into those to be anticipated from the use of ideal apparatus. The procedure is illustrated by means of an example. The accuracy of the corrected signals is then discussed, and it is shown that in some apparatus, as for instance the magnetic resonance spectrometer, predictable optimum conditions occur under which the form of the true output signal may best be determined. Finally the response of the chain of linear units is treated with a view to the correction of the shape and moments of output signals from an apparatus whose resolving power is limited by several independent sources of distortion.

Formulae for non-degenerate Rayleigh–Schrödinger perturbation theory in any order. By R. Huby.

It is shown that Bloch's solution for the nth order perturbation of the energy and the eigenvector in the Rayleigh–Schrödinger perturbation theory of non-degenerate, discrete levels can be cast in a different form, of a kind suggested by Brueckner; and some advantages of the latter form are presented.

The statistical properties of sequences of stochastic pulses. By T. Lukes.

Two methods are presented for treating sequences of random pulses which are applicable to cases where the distribution of periods, durations or intervals is known. The methods are shown to lead to identical results and enable the correlation functions, after-effect functions and spectra to be calculated. The results are applied to typical sequences; some existing results are shown to be particular cases of the theory presented.

Direct interaction with strong coupling in nuclear collisions II. E2 Excitations. By C. B. O. Mohr.

The work of a previous paper on the effect of coupling between elastically and inelastically scattered waves for the case of E0 excitations of the nucleus throughout its volume has been extended to E2 excitations. The inclusion of coupling causes inelastic cross sections to deviate even more from the distorted wave values for E2 excitations than for E0 excitations. The effect is greater for a volume interaction than for a surface interaction of equivalent strength.

The stopping power for alpha particles of ethyl alcohol and carbon tetrachloride in the liquid and vapour states. By R. B. J. Palmer.

Range–energy relations for 8·78 mev alpha particles in ethyl alcohol and carbon tetrachloride in the liquid and vapour states have been determined experimentally using nuclear emulsion and scintillation counting techniques. The range in liquid alcohol was found to be greater than the value previously published. The stopping power for both liquids was found to be different from that of the corresponding vapour, and it is suggested that polarization of the absorbing medium is mainly responsible.

Time resolved absorption studies in a shock tube: a new band system of BaO. By W. H. Parkinson.

Time resolved absorption studies have been carried out through the hot gas behind reflected shock waves during their interaction with powdered barium compounds. A capillary-type flash tube with a short pulse duration and high brightness temperature was used as the background source. A new system of BaO, probably resulting from a $B'\,^1\Pi\text{–}X'\,^1\Sigma$ transition, has been found in absorption and vibrationally analysed.

A band of zinc oxide possibly due to a polyatomic emitter has been recorded in emission from the luminosity produced during the shock excitation of powdered zinc compounds.

The electronic band structure of a model of a cubic crystal. By L. Pincherle and P. M. Lee.

The electronic band structures of a simple cubic and a face-centred cubic array of square potential wells were calculated by a plane wave method for various depths of the potential wells. Certain features of the band structure depend only on the symmetry of the crystal and not on the details of the potential; in a simple cubic monatomic substance an s-type band has its minimum at $\mathbf{k}=0$ and its maximum at $\mathbf{k}=(1,1,1)$; a p-band has its minimum at $\mathbf{k}=(1,0,0)$ and almost certainly its maximum at $\mathbf{k}=(1,1,0)$. In a face-centred monatomic crystal an s-band has its minimum at $\mathbf{k}=0$, while its maximum may be at any of several positions, such as $\mathbf{k}=(2,1,0)$, $\mathbf{k}=(1,0,0)$, $\mathbf{k}=(1,1,0)$, or intermediately. A p-band has its minimum at $\mathbf{k}=(1,1,1)$, with a secondary minimum at $\mathbf{k}=(1,0,0)$, and its maximum at $\mathbf{k}=0$. Various methods of band structure calculation were compared on the example of the lowest level at $\mathbf{k}=0$ for any depth of the potential wells for the face-centred structure. Plane wave methods gave reliable results with least labour.

Differential energy loss and ranges of No, N and He ions. By Dan I. Porat and K. Ramavataram.

The rate of energy loss for ^{20}Ne and ^{14}N ions in the energy region of 0·4 to about 6 mev has been measured in C, Al, Ni, Ag and Au. The ranges of the ions in the above elements were calculated by integrating the differential energy loss taking into account scattering and energy losses due to nuclear collisions. The rate of energy loss for ^4He ions up to 2 mev kinetic energy is reported and range curves in Al, Ni, Ag and Au up to 3 mev are presented. Results on the energy loss of deuterons in Ag are used to extend the presently available data for protons to lower energies. The relative accuracy of the stopping power data is about 1% and the absolute accuracy better than 5%.

The luminescence of CaBr(Tl) and CaI(Tl) as a function of temperature. By J. C. Robertson, J. G. Lynch and W. Jack.

The luminescent efficiencies and decay times of CaBr(Tl) and CaI(Tl) have been studied as a function of temperature in the range $-150°$C to $+150°$C. Protons of energy ~1·4 mev and alpha particles of energy 5·3 mev were used as the exciting radiation. Activation energies for the electron traps in the crystal corresponding to the various decay time components τ_i have been obtained from plots of $\log \tau_i$ against $1/T$, where T is the absolute temperature. It is shown that for optimum particle discrimination by pulse shape analysis, there is no advantage to be obtained by maintaining the crystal of CaI(Tl) or CaBr(Tl) at temperatures other than room temperature.

In addition, measurements have been made at room temperature of the rise time of the luminescence produced in crystals of NaI(Tl), KI(Tl), CaI(Tl) and CaBr(Tl) by protons of energies up to 15 mev and alpha particles of energy 5·3 mev. No variation of rise time with type of particle was observed in any of the crystals examined.

Characteristic electron energy loss spectra of the noble metals and their neighbours. By J. L. Robins.

The characteristic electron energy loss spectra of the elements Zr, Pd, Ag, Au, Zn and Cd have been obtained using the reflection technique and primary electron energies of 1500 and 800 ev. It is observed that, in the second group of transition metals, the relation between the observed plasma losses and the theoretical values is not quite the same as that found previously for the first group of transition metals, in that the observed values are here greater than the theoretical near the beginning of the series. The spectra of the noble metals are complex and show few similarities to one another. The two elements Zn and Cd, which follow noble metals in the periodic table, have very similar spectra and it is obvious that plasma oscillations involving their two valence electrons are still influenced by the recently filled d band.

Electron spin resonance absorption for polycrystalline substances. II. By J. W. Searl, R. C. Smith and S. J. Wyard.

Calculations have been made of the electron spin resonance line shapes for polycrystalline substances showing uniaxial g-value anisotropy. The calculations have been made for both the Lorentzian and Gaussian line shapes of various line-widths. Empirical rules are given for determining $g_\perp$, $g_\parallel$ and the line-width from the experimental line shapes. Line shapes calculated to fit experimental curves from irradiated D_2O_4–D_4O are given.

Partial wave theory of positron–hydrogen atom collisions. By K. Smith.

This paper is concerned with the derivation of the radial equations for positron–hydrogen atom collisions from the continuous state Hartree–Fock equations. The angular coefficients are expressed in terms of vector addition coefficients and Racah coefficients for any angular momentum state of the atomic systems: positronium and atomic hydrogen.

The boundary conditions are written in terms of the S-matrix and expressions are obtained for total and differential cross sections.

LETTERS TO THE EDITOR

Magnetic properties of nickel. By G. C. Fletcher.

Thermoelectricity in metals at normal temperatures—a query. By D. K. C. MacDonald and W. B. Pearson.

A schematic model for the impact excitation of atoms. By B. L. Moiseiwitsch.

A study of superconducting niobium by electron tunnelling. By P. Townsend and J. Sutton.

AUSTRALIA
COMMONWEALTH SCIENTIFIC AND INDUSTRIAL RESEARCH ORGANIZATION

RESEARCH STAFF
(No. 464/233)
(SEVERAL POSITIONS)

The Organization's **Division of Textile Industry, Geelong, Victoria,** invites applications for research positions from Honours graduates in Science, or Engineering with some years post-graduate research experience.

The Division, one of three constituting the Wool Research Laboratories is broadly concerned with development of new physical and chemical techniques in wool textile processing and provides well-equipped laboratories for fundamental studies and full scale mill equipment for application of results. The wide field of research includes absorption studies on wool, fibre friction, permanent setting, shrinkage prevention, mechanical action of machines on wool fibres, servo-control mechanisms in processing and development of new machines.

The appointees will carry out duties in the following fields:—

(i) Chemical studies on modification of wool fibres. This work would involve the study of reactions with a view to developing new fabric finishes;
(ii) The development of new physical methods for separating vegetable material from wool;
(iii) Physical studies on fibre friction, and the effects of lubricants;
(iv) Investigation of new methods of yarn production;
(v) Fibre behaviour in processing using radioactive and high speed photographic techniques.

Applications and enquiries from research workers in fields not strictly related to the above are also warmly invited.

SALARY: Dependent on qualifications and experience within the ranges:—
£A1,510–£A2,265 p.a. or £A2,395–£A2,720 p.a.

EXPERIMENTAL OFFICER
(No. 464/232)

The Organization's **Division of Textile Industry, Geelong, Victoria** also invites applications for a position as Experimental Officer from graduates in Electrical Engineering, or in Science with Physics and Electronics as major subjects (or equivalent professional qualifications). Experience in design of electronic equipment is essential.

The appointee will be required to assume full responsibility for an electronics laboratory. The function of the laboratory will be to develop special electronic devices for application in research on woollen and worsted processing; to advise research staff in projects of an electrical engineering nature; and to provide servicing facilities for all electronic equipment of the Division. First class laboratory facilities available.

SALARY: Dependent on qualifications and experience within the ranges:—
£A1,620–£A1,950 p.a. or £A2,070–£A2,330 p.a.

Salary for a woman will be £A180 p.a. less than corresponding rates for men.

Promotion within C.S.I.R.O. is by merit and may ultimately go beyond the upper limit of the range within which the original appointment is made.

Fares paid. *Further particulars supplied on application to:*—
Mr. E. J. Drake, Chief Scientific Liaison Officer, Australian Scientific Liaison Office, Africa House, Kingsway, LONDON, W.C.2.
to whom applications (quoting relevant Appointment number) should be addressed by **August 26, 1961.**

COLLEGE OF ADVANCED TECHNOLOGY BIRMINGHAM

DEPARTMENT OF PHYSICS

Applications are invited for the posts of

RESEARCH FELLOW AND RESEARCH ASSISTANTS in the fields of Fluctuation, Shot Noise and Flicker Effect, Electron Space Charges, Information Theory, Wave Optics or Nuclear Emulsion Studies.

Candidates for Research Fellowships must either have shown exceptional promise in research in science or technology, or in industrial experience relevant to the proposed subject for research. They should possess a good first degree, and a higher degree gained as the result of research work; or possess a college associateship or Diploma in Technology or appropriate professional qualification followed by exceptionally valuable and interesting industrial experience, or appropriate research work in industry, research associations or government establishments. Candidates should submit their own research proposals for consideration. The appointment will be normally tenable for three but not more than four years.

Candidates for Research Assistantships should possess a Diploma in Technology, a university degree or equivalent qualification. The research work carried out may normally be submitted for a higher degree or other appropriate alternative higher qualifications. The appointment will normally be tenable for two years but may be renewed for not more than one further year.

Salary Scales:

RESEARCH FELLOWS:

£700–£1,150

With graduate and training allowances where applicable.

Further details can be given on the basis of the applicant's biographical data. As an indication, it may be noted that an applicant with a good honours degree, or a Ph.D. gained as the result of five years' approved full-time study would have a starting salary of about £955.

RESEARCH ASSISTANTS:

£600–£650.

Further particulars and forms of application from the Bursar, College of Advanced Technology, Gosta Green, Birmingham 4. Applications to be received within 14 days of this advertisement. Please quote "V".

K. R. PILLING,
Clerk to the Governors.

SEMICONDUCTOR RESEARCH & DEVELOPMENT

If you are a PHYSICIST, CHEMIST, DESIGN DRAUGHTSMAN or an ENGINEER, you can take a leading part in the immediate expansion of the Company in the field of semiconductor devices.

This is an exceptional opportunity both for those entering and those already established in the industry, and offers positions of responsibility, carrying substantial salaries, in the world's fastest growing industry.

Applications for these appointments should be made to C. S. V. Salt.

WESTINGHOUSE

82 YORK WAY
LONDON N.1

A vacancy has arisen in a well-established firm of consultants and research laboratories for

SENIOR SCIENTIST/RESEARCH ADMINISTRATOR

(electrical materials and components)

The successful applicant will be responsible for a section of the laboratories dealing with various research and development projects in electrical materials and components. The post involves technical, as well as administrative responsibilities, and experience in the planning and directing of research projects, also writing of reports, etc., is necessary.

The position offers unusual technical and administrative scope, and carries a commensurate senior salary.

Informal interviews can be arranged in Sunbury or London; evening or week-end appointments may be made if required.

G. V. Planer Ltd., Windmill Road, Sunbury-on-Thames, Middlesex (Sunbury 2266).

IMPERIAL CHEMICAL INDUSTRIES LIMITED
DYESTUFFS DIVISION
has a vacancy in their Research Department at Manchester for an

HONOURS GRADUATE IN MATHEMATICS

to increase the mathematical effort applied to the Division's problems. The Dyestuffs Division's interests are the most varied of all those in the Company. It manufactures over 6,000 different chemical products which include, besides several hundred dyestuffs, nylon, rubber chemicals, textile auxiliaries, polyurethanes and other polymers. Current research is designed to extend the fundamental understanding of the physical and chemical factors which produce the many different technical effects, as well as into analysis, from a mathematical angle, of the processes themselves. Investigations are in progress into such different topics as theoretical physics, quantum chemistry, polymerisation kinetics, and the theory of elasticity. The post offers scope for a wide range of interest and there are excellent prospects of promotion.
The Company operates a 5-day, 37½ hour week, a Pension Fund, and an Employees' Profit Sharing Scheme. Assistance can be given towards housing and removal expenses.
Applicants should quote reference I.93. Forms may be obtained from the Staff Manager, Hexagon House, Blackley, Manchester, 9.

Good Scientists are Individuals

SCIENTISTS, *like everyone else, like to be treated as individuals. This fact we believe is essential to creative effort, whether for fundamental research or applied work.*

British Nylon Spinners Limited appreciate individuality—and adopt a personal relationship with all the 230 graduate scientists employed at BNS in production, textile research and development, and pure and applied research.

This approach underlies the success of Nylon Yarn, whose multitude of end uses varies from tough flexible hawsers, conveyor belts and air houses to the flimsiest and most delicate of materials.

The research ranges:—

In the Chemistry field—from the investigation of new fibre forming polymers, through the exploration of the properties of nylon, as a material and as a textile fibre, to applied problems in dyeing, heat setting and specialised finishing. The work involves fundamental investigation on the kinetics of crystallisation of polymer, its oxidative and photo-chemical breakdown, its surface and co-ordination chemistry and sorption in high polymer systems.

In the Physics field—from the study of molecular structures of polymer to the particular properties of a yarn for a new end use, such as tyre cord and safety equipment. There is scope for the spectroscopist and X-ray crystallographer; for physicists interested in electrical properties, and in conduction mechanisms of materials of very high resistivity, and of their dielectric behaviour. Interest in the visual appearance of nylon leads to a study of light reflection and scattering properties and to studies of microscopic and interferometric methods.

Chemists, Physicists and textile Technologists work as teams to blend the strict scientific discipline of the former with the knowledge and expertise of the latter.

If you are interested, come to see us and talk to our Scientists. Please write, quoting R29, to the Personnel Manager,

British Nylon Spinners Limited

PONTYPOOL · MONMOUTHSHIRE

PHYSICISTS

BCL

Vacancies exist in the

Research & Development Division

of

BRITISH CELLOPHANE LIMITED

The first is for a man under 30, with a Ph.D. and a 1st or good 2nd class honours degree, and having proven experimental ability. The work is concerned with the mechanical, optical, surface and barrier properties of polymer films, the relation between these properties and the fine structure of the films.

The second is for a practical physicist with a flair for electronic instrumentation, to work on the origination, design, construction and testing of prototype instruments, primarily for research use, but in some cases for use in production. Applicants should be under 35, and have a good honours degree, with practical experience in this or related fields.

Both these posts offer considerable scope to applicants with creative ability, and originality of mind. Attractive salaries will be offered to the selected applicants, and working conditions in new and well-equipped laboratories are good.

Please write, specifying for which post application is being made, to the

Personnel Officer,
Bath Road, Bridgwater,
Somerset.

Reed

The expanding Group Research department with new laboratories nearing completion requires

TWO CLASSICAL PHYSICISTS

1. **To research into the strength properties of paper products.**
2. **To study the formation of paper webs.**

Both posts will involve the use of electronic and optical techniques.

The successful candidates will be chosen from those offering a good honours degree, research experience and the capacity for promotion either in research or production.

Attractive salaries will be offered. A non-contributory pension scheme is operated by the Group and assistance with house purchase can be arranged.

Written applications should be addressed to:-

The Group Personnel Officer, Albert E. Reed & Co. Ltd., Larkfield, Nr. Maidstone, Kent.
quoting reference TCP/GR/17.

THE HARRIS COLLEGE PRESTON

Principal: H. WILKINSON M.Sc.Tech., Ph.D., A.Inst.P.

DEPARTMENT OF PHYSICS AND MATHEMATICS
SENIOR LECTURER IN PHYSICS

Applications are invited for the above post from well qualified persons with relevant experience. The position is the senior teaching post in Physics under the Head of the department which will shortly move into new and extensive premises, and is concerned with work in Pure and Applied Physics up to the level of the Graduateship examination of the Institute.

There is scope for the development of new courses especially in Applied Physics related to National Certificate courses with a bias towards Instrumentation and Control.

Salary in accordance with the Burnham Technical Report. Senior Lecturer: £1,550 × £50–£1,750. Further particulars and application forms from the Principal, to whom they should be returned as soon as possible.

W. R. TUSON, B.Sc.,
Clerk to the Harris Council.

BOROUGH POLYTECHNIC

BOROUGH ROAD, LONDON, S.E.1.

Principal:
JAMES E. GARSIDE, M.Sc.Tech., Ph.D., F.R.I.C., F.I.M. F.Inst.F.

The Governors invite applications for the following appointment.

Department of Electrical Engineering and Physics

Head of Department:
V. PEREIRA-MENDOZA, M.Sc.Tech., M.I.E.E.

LECTURER IN PHYSICS

Applicants should be University Graduates in Physics with industrial and/or research experience in Radiation Protection or a kindred subject. Teaching experience is also desirable. Research will be encouraged and facilities made available.

Salary Scale:

£1,370 p.a. by annual increments of £35 to a maximum of £1,550 p.a., plus "London Allowance" of £38 or £51 according to age.

Further particulars and Application Form obtainable on application to the undersigned.

FREDK. J. PACKER,
Clerk to the Governing Body

UNIVERSITY OF READING

Applications are invited for (i) a LECTURERSHIP (GRADE I) IN THEORETICAL PHYSICS, (ii) a LECTURERSHIP (GRADE I) IN PHYSICS and (iii) a LECTURERSHIP (GRADE II) IN PHYSICS. Posts (ii) and (iii) are open to both theoretical and experimental physicists. It is expected that at least one appointment will be made in July and one in September. Applications from persons not able to take up an appointment until October, 1962, will be considered. Applications should be sent, as soon as possible, to The Registrar (Room 22, O.R.B.), The University, Reading, from whom further particulars may be obtained.

UNIVERSITY OF BRISTOL

Applications are invited for a Research Appointment in the H. H. Wills Physical Laboratory for work on Crystallinity of Polymers. Applicants should have experience either in the physics or physical chemistry of polymers or research on the structure or properties of solids in general. Salary within the range £800 to £1,100 p.a. Fuller particulars may be had from the Registrar The University, Bristol 8, to whom applications should be sent by July 20.

THE CEMENT AND CONCRETE ASSOCIATION

invites applications from

PHYSICISTS

to carry out independent research and to take an interest in a broad range of applications of physics to the building industry.

The work of the Physics Group of the Materials Research Department includes fundamental studies of the properties of matter and strength of materials, measurement of heat flow, strain gauging, X-ray diffraction analysis and design of instruments.

Scope exists for long-term work at the fundamental level as well as on applied physics projects and the facilities include a Sirius computer.

The publication of results and attendance at scientific meetings is encouraged. The appointment will be made in the career range of £1,000–£2,000 with possibilities of further advancement, and the post is permanent and pensionable.

Applications to Dr. A. R. Collins, Director of Research and Technical Services, Cement and Concrete Association, Wexham Springs, Stoke Poges, Buckinghamshire.

UNIVERSITY OF CAPE TOWN
South Africa

CHAIRS OF MATHEMATICS

Applications are invited for two Chairs of Mathematics, from candidates qualified in the field of pure mathematics, applied mathematics or mathematical statistics. The salary scale is R4,600 × 200–5400 (£2,300 × £100–£2,700) per annum. Applicants should state age, experience, academic qualifications, research work completed or in progress, and should give the names of two referees whom the University may consult. Two copies of the application (accompanied by a recent photograph) and testimonials should reach the Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (from whom memoranda giving the general conditions of appointment including transport expenses on appointment and information on the work of the department may be obtained) not later than August 14, 1961. An additional copy should be sent direct by airmail to the Registrar, University of Cape Town, Private Bag, Rondebosch, Cape Town, South Africa to reach him by the same date. The University reserves the right to appoint a person other than one of the applicants or to make no appointment.

NATIONAL INSTITUTE FOR RESEARCH IN DAIRYING
(University of Reading)

Assistant Experimental Officer required in Physics department to assist in studies of physical properties of dairy products—butter and cheese, etc. He will also be required to construct and modify experimental testing equipment in the department workshop, and skill in using a lathe would be advantageous. Candidates should possess H.N.C. or pass degree, or, if under 22, G.C.E. "A" level or equivalent. Starting salary within range £450 10s. (at 18) to £776 (at 26) in scale to £983; pension scheme. Apply, naming two referees to Secretary, N.I.R.D., Shinfield, Reading. Quote ref. 61/4.

NATIONAL INSTITUTE FOR RESEARCH IN DAIRYING
(University of Reading)

Applications are invited for the following posts, tenable for five years from October 1, 1961, under a grant from the United States National Institutes of Health, for work on the flow and the coagulation of blood.

1. Principal Scientific Officer, with training in physiology and/or biochemistry, and preferably also in Physics. Experience in work on blood an advantage. Salary within range £1,666–£2,418; F.S.S.U.
2. Assistant Experimental Officer preferably with pass degree or equivalent and experience in biological work. Salary range £450 10s. to £983.

Further particulars from the Secretary, N.I.R.D., Shinfield, Reading. Quote ref. 61/18 for post 1 or 61/19 for post 2.

ALUMINIUM LABORATORIES LIMITED
(The Research and Technical Organization of the international ALCAN Group of Companies)

Experienced PHYSICIST required for the post of HEAD of the PHYSICS DIVISION at Banbury Laboratories. This Division is engaged on a variety of problems related to the production and use of aluminium alloys. The position is suitable for a man who has reached the stage in his career where he is able to plan and supervise the work of teams of research physicists. Working conditions are excellent. Pension and Life Assurance Scheme in operation. Please apply to: Personnel Officer, Aluminium Laboratories Limited, Banbury, Oxon.

COURSES

MIDDLESEX COUNTY COUNCIL
Education Committee
HENDON TECHNICAL COLLEGE
The Burroughs, Hendon, N.W.4
Telephone: HENdon 6061
Principal:
Dr. E. Williams, B.Sc., F.R.I.C.

DEPARTMENT OF ELECTRICAL ENGINEERING
Session 1961-1962
Commencing September 25, 1961

Sandwich Courses

3 Year Course for Higher National Diploma in Applied Physics providing comprehensive study in all aspects of Physics and detailed work in Electronics.

For these courses students may be "works-based" or "college-based". "College-based" students are eligible to apply for local authority awards and grants; and the College assists students to obtain suitable industrial experience during the non-college period each year. Immediate application for admission to the above course should be made to the Principal at the college, from whom further particulars are available.

PRINTED BY F. J. MILNER AND SONS LIMITED, BRENTFORD AND LONDON.